REMARKS

I. Information Disclosure Statement (IDS)

IDS Filed August 14, 2006

The Office Action dated August 14, 2006 (i.e., hereinafter referred to as the "Office Action") indicated that the Information Disclosure Statement (IDS) filed on August 14, 2006 fails to comply with 37 CFR 1.98(a)(1). The Examiner indicated that the information disclosure statement has been placed in the application file, but the information referred to therein has not been considered.

The Applicant notes that the documents submitted with the August 14, 2006 amendment/response were supplied to the Examiner in response to the Examiner's note in the prior office action that the originally submitted information disclosure statement documents contained various errors or were misidentified, etc. That is, the Examiner had noted that the information disclosure statement filed January 29, 2004 failed to comply with 37 CFR 1.98(a)(2) in addition to the information disclosure statement filed on October 7, 2005. The documents submitted with the August 14, 2006 amendment/response were thus provided to the Examiner to enable the Examiner to fully review and consider the documents that the Examiner did not consider due to the Examiner's noted deficiencies with respect to the previously submitted information disclosure statements.

The Applicant is therefore re-submitting that this information disclosure statement to contain all of the following:

(1) a list of all patents, publications, or other information submitted for consideration by the Office

(2) U.S. patents and/or U.S. patent application publications listed in a section separately from citations of other documents

(3) The application number of the application in which the information disclosure statement is being submitted on each page of the list;

(4) a column that provides a blank space next to each document to be considered, for the Examiner's initials; and

(5) a heading that clearly indicates that the list is an information disclosure statement.

The Applicant is therefore re-submitting the documents previously submitted with the August 14, 2006 amendment/response in the context of a complete information disclosure statement. These documents were also previously submitted with the original and supplemental information disclosures statements, but the Examiner refused to consider these documents. The Applicant respectfully requests entry of this information disclosure statement and references and an acknowledgement that the information disclosure statements previously submitted are now complete.

IDS filed January 29, 2004

The Examiner also indicated that IDS filed on January 29, 2004 fails to comply with 37 CFR 1.98(a)(2), which requires a legible copy of each cited foreign patent document; each non-patent literature publication or that portion which caused it to be listed; and all other information or that portion which caused it to be listed. The Examiner indicated that the IDS filed on January 29, 2004 has been placed in the application file, but the information referred to therein has not been considered. The Examiner referred to the following items from the IDS dated January 29, 2004:

Page 1 of 7: The Examiner indicated that the document number 6,282,530 does not have the correct date and therefore does not know which patent application is intended to list. The Applicant is submitting herewith a copy of U.S.

Patent No. 6,282,530 with the enclosed IDS Form 1449 submittal. So that there can be no question as to which patent the Applicant intends to list, U.S. Patent No. 6,282,530 is entitled "Digital Neural Node" and issued to Shi-Fong Huang on August 28, 2001. It is believed that the submission of this document via the enclosed IDS Form 1449 submittal now complies with 37 CFR 1.98(a)(2).

Page 2 of 7: The Examiner indicated that the document number EP 1 069 206 A2 does not have the correct date and therefore does not know which patent application is intended to list. The Applicant is therefore again submitting herewith a copy of EP 1 069 206 A2 with the enclosed IDS Form 1449 submittal. So that there can be no question as to which patent the Applicant intends to list, European Patent Application Publication No. EP 1 069 206 A2 is entitled "Nanoscale Conductive Connectors and Method for Making the Same" and was published by the European Patent Office on January 17, 2001. It is believed that the submission of this document now complies with 37 CFR 1.98(a)(2) via the enclosed IDS Form 1449 submittal.

Page 3 of 7: The Office Action indicated that the other prior art "Nanotubes for Electronics", page 69 is missing. The Applicant is again submitting herewith a complete copy of this article. It is believed that the submission of this document now complies with 37 CFR 1.98(a)(2) via the enclosed IDS Form 1449 submittal.

The Office Action also indicated that the other prior art "Aligning single-wall carbon nanotubes with an alternating current electric field" is missing. The Applicant is submitting herewith a copy of this article. It is believed that the submission of this document now complies with 37 CFR 1.98(a)(2) via the enclosed IDS Form 1449 submittal.

Page 4 of 7: The Examiner indicated that the other prior art "Purification of Single Wall Carbon Nanotubes by Microfiltration", page 8842 is missing. The Applicant submits that page 8842 is merely an additional listing of reference. The Applicant does not have a copy of the missing page 8842. The Applicant only has a copy of the article that extends from pages 8839 to 8841, which was submitted to the Examiner with the previous amendment/response and in the original IDS. The Applicant is again submitting herewith a copy of this article (pages 8839 to 8841). It appears, however that the text of the article "Purification of Single Wall Carbon Nanotubes by Microfiltration" ends on page 8841 rather than page 8842 and that the reference to page 8842 as the ending page of the document for consideration by the Examiner should actually have been page 8841. It is believed that the submission of this document now complies with 37 CFR 1.98(a)(2) via the enclosed IDS Form 1449. The Applicant requests that the Examiner enter and consider this article from pages 8839-8841. The Applicant also requests that the Examiner acknowledge that the Examiner has reviewed and considered this reference.

Page 5 of 7:

The Examiner indicated that the other prior art "Evolution of Avalanche Conducting States in Electrorheological Liquids" is duplicate with item #2 on page 4 of 7. So that there can be no question about the opportunity for the Examiner to review this article or find error in its citation, the Applicant is again submitting herewith a complete copy of this article. It is believed that the submission of this document via the enclosed Form 1449 IDS now complies with 37 CFR 1.98(a)(2).

The Office Action indicated that the other prior art "Rapid Communication Orientation and Purification of Carbon Nanotubes Using AC Electrophoresis" is missing. The Applicant is submitting herewith a complete copy of this article. It is believed that the submission of this document with the enclosed Form 1449 IDS now complies with 37 CFR 1.98(a)(2).

Page 7 of 7: the Examiner indicated that the other prior art "Building Blocks for Electronic Spiking Neural Networks" is duplicate with the last item on this page. The Applicant is submitting herewith a copy of this article. It is believed that the submission of this document with the enclosed Form 1449 IDS now complies with 37 CFR 1.98(a)(2).

These documents are being submitted with the Information Disclosure Statement submitted herewith. As such, the Applicant should now review and consider these documents. Also, the Applicant believes that it is not necessary to resubmit the entire contents of the information disclosure statement submitted January 29, 2004, only the items that were missing or incorrectly listed. The Applicant therefore requests that the Examiner review and consider the entire contents of the information disclosure statement submitted January 29, 2004, given the submission of the present IDS, which contains the missing or incorrectly listed references.

IDS Filed October 7, 2005

The Examiner indicated that the IDS filed on October 7, 2005 fails to comply with 37 CFR 1.98(a)(2), which requires a legible copy of each cited foreign patent document; each non-patent literature publication or that portion which caused it to be listed; and all other information or that portion which caused it to be listed. The Examiner indicated that it has been placed in the application file, but the information referred to therein has not been considered.

The Examiner indicated that the other prior art "Nanoparticles Get Wired" is missing. The Applicant submitted this article to the Examiner in the last amendment/response for consideration and review by the Examiner. However, the Examiner again submits that document to the Examiner and is doing so in association with the IDS Form 1449 submitted herewith.

The Applicant further notes that with the submission of this updated Form 1449 IDS and previously missing or incorrectly identified references, the Examiner now has available the complete listing of references that were already submitted or identified in the previously submitted information disclosure statements. The presently submitted IDS 1449 is submitted to correct the aforementioned deficiencies that the Examiner noted with respect to previously submitted information disclosure statements. Additionally, the Applicant notes that the Examiner has already acknowledged and considered all other references previously submitted. This is evidenced from the various originally submitted Form 1449 IDS sheets, which are contained in the application file on record with the U.S. Patent & Trademark Office. Thus, there is no need to re-submit any document already acknowledged by the Examiner via the Examiner's initials on previously submitted information disclosure statements, only the documents that are being submitted herewith.

II. Claim Rejections 35 U.S.C. § 102

Requirements for Inherency-Based Anticipation

There are a number of factors that must be considered when attempting to establish inherency as a basis for anticipation. Inherency should only be applied under very limited circumstances. That is, inherency permits in very limited circumstances, an invention to be anticipated by prior art that is lacking minor, well-known features in the claimed invention. If the "missing subject matter" is "inherent" or necessarily disclosed in the prior art reference, then anticipation can exist. As stated by the Federal Circuit (see In re Sun USPQ2d 1451, 1453 (Fed. Cir. 1983)

> ...To serve as an anticipation when the reference is silent about the asserted inherent characteristic, such gap in the reference may be filled with recourse to intrinsic evidence. Such evidence must make clear that the missing descriptive matter is necessarily present in

the thing described in the reference and that it would be so recognized by persons of ordinary skill.

In this regard, the CCPA has added that "'[i]nherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient". See In re Oelrich, 666 F.2d 578, 581, 212 USPQ 323, 326 (C.C.P.A. 1981) (quoting Hansgrig v. Kemmer, 102 F.2d 212, 214, 40 USPQ 665, 667 (C.C.P.A. 1930). That is, the missing element or function must necessarily result from the prior art reference.

Additionally, when an Examiner's rejection relies on inherency, it is incumbent upon the Examiner to point to the page and line of the prior art that justifies the rejection based on an inherency theory. The Examiner must not leave the Applicant to guess at the basis of the inherency rejection.

The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. *In re Rijckaert*, 9 F.3d 1531, 1534, 28 USPQ2d 1955, 1957 (Fed. Cir. 1993) (reversed rejection because inherency was based on what would result due to optimization of conditions, not what was necessarily present in the prior art); *In re Oelrich*, 666 F.2d 578, 581-82, 212 USPQ 323, 326 (CCPA 1981). "To establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.' " *In re Robertson*, 169 F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999) (citations omitted).

"In relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teachings of the applied prior art." *Ex parte Levy,* 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Inter. 1990) (emphasis in original).

Requirements for Prima Facie Anticipation

A general definition of *prima facie* unpatentability is provided at 37 C.F.R. §1.56(b)(2)(ii):

> A *prima facie* case of unpatentability is established when the information *compels a conclusion* that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability. (*emphasis added*)

"Anticipation requires the disclosure in a single prior art reference of each element of the claim under consideration." *W.L. Gore & Associates v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303, 313 (Fed. Cir. 1983) (citing *Soundscriber Corp. v. United States*, 360 F.2d 954, 960, 148 USPQ 298, 301 (Ct. Cl.), *adopted*, 149 USPQ 640 (Ct. Cl. 1966)), *cert. denied*, 469 U.S. 851 (1984). Thus, to anticipate the applicants' claims, the reference cited by the Examiner must disclose each element recited therein. "There must be no difference between the claimed invention and the reference disclosure, as viewed by a person of ordinary skill in the field of the invention." *Scripps Clinic & Research Foundation v. Genentech, Inc.*, 927 F.2d 1565, 18 USPQ 2d 1001, 1010 (Fed. Cir. 1991).

To overcome the anticipation rejection, the Applicant needs to only demonstrate that not all elements of a *prima facie* case of anticipation have been met, *i.e.*, show that the prior art reference cited by the Examiner fails to disclose every element in each of the applicants' claims. "If the examination at the initial state does not produce a prima face case of unpatentability, then without more the applicant is entitled to grant of the patent." *In re Oetiker*, 977 F.2d 1443, 24 USPQ 2d 1443, 1444 (Fed. Cir. 1992).

Thakoor, et al.

Claims 1-7, 9-11, and 13-20 were rejected by the Examiner under 35 U.S.C. 102(b) as being anticipated by Thakoor et al (hereinafter referred to as "Thakoor"), "Solid-state thin-film memistor for electronic neural networks".

Regarding claim 1, the Examiner argued that Thakoor teaches a system, comprising:

a physical neural network configured utilizing nanotechnology (the Office Action cited "title" in support of this argument), wherein said physical neural network comprises a plurality of nanoconductors suspended and free to move about in a dielectric medium (citing page 3132, right column, lines 10-12; and page 3133, right column, lines 3-5 Thakoor) and which form neural connections between pre-synaptic and post-synaptic components of said physical neural network (citing page 3132, left column, lines 24-41 of Thakoor in support of this argument); and

a learning mechanism for applying Hebbian learning to said physical neural network (the Examiner cited page 3133, left column, lines 1-14 of Thakoor in support of this argument).

Thakoor does not teach, disclose, suggest and/or anticipate all of the claim limitations of claim 1 including: a physical neural network, nanotechnology, nanoconductors, a dielectric medium in which nanoconductors are free to move about, and a learning mechanism for applying Hebbian learning. Additionally, it is significant as will be discussed in greater detail herein that the memistor of Thakoor is neither a synapse nor a neural network. The memistor of Thakoor is also not an adaptive learning device but rather a programmable analog memory element.

Regarding the issue of a physical neural network, Thakoor discusses and discloses neural networks and neural network components in general but does not actually show or illustrate an actual physical neural network. The memistor of Thakoor is not a physical neural network or a synapse as will be explained shortly. The left column, paragraphs 1-3, page 3132 of Thakoor generally discusses neural

networks and neurons, but does not provide for an actual illustration or discussion of a specific neural network and how such a neural network would be implemented.

The remaining portions of Thakoor deal with a discussion of Thakoor's memistor device and illustrates at FIG. 3, a circuit diagram of a circuit that performs an autonulling function, including the memistor in association with the neuron to be autonulled. The illustration of FIG. 3 of Thakoor, however, is not that of a physical neural network, but simply a neuron in association with the memistor. Thakoor only indicates that the electrochemical analog memory effects of the memistor device "...in solid state devices are potentially useful in electronic neural networks for adaptive learning and optimization applications". In other words, the memistor is useful for use in a physical neural network, but in and of itself is not a physical neural network. The memistor is merely one of many devices/components that could be adapted for use with a neural network. For example, a resistor is a device that finds usefulness in a neural network. Similarly, a transistor is a device that is useful in electronic neural networks. Such devices are in and of themselves <u>not</u> neural networks. By attempting to equate the memistor with a physical neural network, the Examiner is making an incorrect comparison to a device that is fundamentally different from a physical neural network. A more appropriate comparison for a memistor would be devices such as transistors or resistors that complement the use of a neuron or other physical neural network components.

Regarding the issue of nanotechnology, it is clear from a review of Thakoor that <u>nanotechnology</u> is not taught by Thakoor. The Examiner has asserted that Thakoor teaches nanotechnology and refers to the use of ions by Thakoor as a basis for this argument, asserting that the ions are inherently the same as Applicant's nanoconductors. The H+ ions of Thakoor and "ions" in general do not constitute nanoconductors/nanoparticles as taught by Applicant's invention. In order to understand why such "ions" are not nanoconductors/nanoparticles as taught by Applicant's invention, the Applicant believes that it would be helpful to the Examiner

to understand what actually constitutes "nanotechnology" and what does not. A general discussion of "nanotechnology" is provided in Applicant's "background" section as follows:

"The term "Nanotechnology" generally refers to nanometer-scale manufacturing processes, materials and devices, as associated with, for example, nanometer-scale lithography and nanometer-scale information storage. Nanometer-scale components find utility in a wide variety of fields, particularly in the fabrication of microelectrical and microelectromechanical systems (commonly referred to as "MEMS"). Microelectrical nano-sized components include transistors, resistors, capacitors and other nano-integrated circuit components. MEMS devices include, for example, micro-sensors, micro-actuators, micro-instruments, micro-optics, and the like.

In general, nanotechnology presents a solution to the problems faced in the rapid pace of computer chip design in recent years. According to Moore's law, the number of switches that can be produced on a computer chip has doubled every 18 months. Chips now can hold millions of transistors. However, it is becoming increasingly difficult to increase the number of elements on a chip using present technologies. At the present rate, in the next few years the theoretical limit of silicon based chips will be reached. Because the number of elements, which can be manufactured on a chip, determines the data storage and processing capabilities of microchips, new technologies are required which will allow for the development of higher performance chips.

Present chip technology is also limited in cases where wires must be crossed on a chip. For the most part, the design of a computer chip is limited to two dimensions. Each time a circuit is forced to cross another circuit, another layer must be added to the chip. This increases the cost and decreases the speed of the resulting chip. A number of alternatives to standard silicon based complementary metal oxide semiconductor ("CMOS") devices have been proposed. The common goal is to produce logic devices on a nanometer scale. Such dimensions are more commonly associated with molecules than integrated circuits.

Integrated circuits and electrical components thereof, which can be produced at a molecular and nanometer scale, include devices such as carbon nanotubes and nanowires, which essentially are nanoscale conductors ("nanoconductors"). Nanoconductors are tiny conductive tubes (i.e., hollow) or wires (i.e., solid) with a very small size scale (e.g., 0.7 to 300 nanometers in diameter and up to 1mm in length). Their structure and fabrication have been widely reported and are well known in the art. Carbon nanotubes, for example, exhibit a unique atomic arrangement, and possess useful physical properties such as one-dimensional electrical behavior, quantum conductance, and ballistic electron transport.

Carbon nanotubes are among the smallest dimensioned nanotube materials with a generally high aspect ratio and small diameter. High-quality single-walled carbon nanotubes can be grown as randomly oriented, needle-like or spaghetti-like tangled tubules. They can be grown by a number of fabrication methods, including chemical vapor deposition (CVD), laser ablation or electric arc growth. Carbon nanotubes can be grown on a substrate by catalytic decomposition of hydrocarbon containing precursors such as ethylene, methane, or benzene. Nucleation layers, such as thin coatings of Ni, Co, or Fe are often intentionally added onto the substrate surface in order to nucleate a multiplicity of isolated nanotubes. Carbon nanotubes can also be nucleated and grown on a substrate without a metal

nucleating layer by using a precursor including one or more of these metal atoms. Semiconductor nanowires can be grown on substrates by similar processes."

The aforementioned language generally describes what is meant by "nanotechnology". Applicant's invention provides a number of examples of what constitutes "nanoconductors". Notice that the description above describes nanoconductors are as tiny conductive tubes (i.e., hollow) or wires (i.e., solid) with a very small size scale (e.g., 0.7 to 300 nanometers in diameter and up to 1mm in length). Page 22, paragraph [0088] of Applicant's invention further indicates the following:

> Nanoconductors can be provided in a variety of shapes and sizes without departing from the teachings herein. A nanoconductor can also be implemented as, for example, a molecule or groups of molecules. A nanoconductor can also be implemented as, for example, DNA.

Of course, it is understood by those in the nanotechnology arts that variations to the aforementioned description of nanotechnology are likely to arise. Applicant's specification, however, can be utilized as a general guideline for the context of "nanotechnology" in which Applicant's invention is provided. As a general rule, Applicant's claims need to be interpreted in light of Applicant's specification.

With this in mind, Applicant has provided various examples of nanoconductors in Applicant's specification. For example, the Applicant has referred to nanotubes, nanowires, nanoparticle and even DNA. For example, Applicant's specification at paragraph [0087] indicates that "...Examples of nanoconductors include devices such as, for example, nanowires, nanotubes, and nanoparticles". Applicant's paragraph [0087] also indicates that "The network of nanoconnections depicted in FIG. 3 can be implemented as a network of molecules, including, for example, nanoconductors." Applicant's specification at paragraph [0088) also indicates the following:

"Nanoconnections 304, which are analogous to biological synapses, can be composed of electrical conducting material (i.e., nanoconductors). Nanoconductors can be provided in a variety of shapes and sizes without departing from the teachings herein. A nanoconductor can also be implemented as, for example, a molecule or groups of molecules."

Paragraph [0089] of Applicant's specification also indicates that carbon particles (e.g., granules or bearings) can also be utilized for developing the Applicant's nanoconnections. The various types of "nanoconductors" described above and by Applicant have several key features in common. First, they are not ions and are all multi-atom structures. Thus, Applicant's use of nanotechnology-based devices and components relates to multi-atom structures that are built (man-made or natural) or synthesized. DNA, for example, is a naturally constructed multi-atom structure. Free floating ions are not such structures. Atoms and atomic ions do not represent nanoparticles/nanoconductors because "nanotechnology" seeks to use atoms as the <u>building blocks</u> of multi-atom structures.

In this light, the H+ ion of Thakoor is <u>not</u> a nanoconductor as taught by Applicant's invention, but rather simply just that -- an ion. Thus, it is not proper to identify the <u>ions</u> of Thakoor as anticipating the <u>nanoconductors</u> of Applicant's invention because one skilled in the art would <u>not</u> recognize an ion as constituting such a nanoconductor (i.e., built or synthesized multi-atom structures such as DNA, nanotubes, nanowires, etc). Simply because a reference teaches the use of ions would not lead one skilled in the art to conclude that such ions are the same as components such as nanotubes, nanowires, DNA etc. In order to inherently anticipate Applicant's invention, the use of multi-atom structures such as DNA, nanotubes, nanowires and such nanoconductors must necessarily flow from the teachings of the Thakoor and in particular from the H+ ions as argued by the Examiner. It is clear that from a strict prima facie anticipation standpoint, Thakoor does not disclose, teach or suggest nanotechnology-based nanoconductors such as nanotubes, nanowires, DNA, etc. From an inherency-based anticipation standpoint,

it also clear Thakoor does not inherently anticipate the nanoconductors taught by Applicant's invention. This is so because Examiner has not provided a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic of nanoconductors (e.g., nanotubes, nanowires, DNA, etc., as taught by Applicant's invention) necessarily flows from the teachings of the applied prior art, i.e., Thakoor's H+ ions.

Regarding the dielectric medium of Applicant's invention in which the nanoconductors are free to move about, there is no teaching, suggestion or disclosure of the use of such a dielectric medium with nanoconductors disposed therein by Thakoor. The Examiner cited page 3132, right column, lines 10-12; and page 3133, right column, lines 3-5 in support of the assertion that Thakoor anticipates a dielectric medium in which nanoconductors are free to move about.

Page 3132, right column, lines 10-12 indicates that "a thin film of hygroscopic chromium trioxide (Cr_2O_3) serving as a hydrogen ion source is deposited by reactive magnetron sputtering".

Page 3133, right column, lines 3-5 indicates that "...since the Cr_2O_3 film serves as a source of H+ions, its ability to absorb and retain water is crucial to the device operation".

The Examiner is therefore asserting that Thakoor uses chromium trioxide (Cr_2O_3) as a dielectric medium in which nanoconductors (as taught by Applicant's specification) are disposed and free to move about. This is simply not the case. The Cr_2O_3 of Thakoor is used as a hydrogen ion source and not as a dielectric medium. One of the key features of Applicant's claims is that Applicants nanoconductors are disposed and free to move about with Applicant's dielectric medium. Chromium trioxide as used by Thakoor is a solid. How can nanoconductors (e.g., nanotubes, nanowires, DNA, etc.) move freely about in a solid? In order to appreciate why the chromium trioxide of Thakoor is not used as a dielectric medium, the Applicant believes it would be helpful to discuss what a

dielectric is and is not and also analyze some of the properties inherent to chromium trioxide.

A dielectric is a material that tends to concentrate an applied electric field within itself. As the dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. Thus, in order for the chromium trioxide of Thakoor to be used for the purpose of providing a dielectric medium, the chromium trioxide must be used for the purpose of concentrating an applied electric field within itself and other dielectric properties as indicated above. Again, Thakoor is not using the chromium trioxide for this purpose. Thakoor is using the chromium trioxide as a hydrogen ion source as part of an electrolytic electrochemical process/system, as opposed to the dielectric electromechanical process/system of Applicant's invention.

Additionally, the chromium trioxide (Cr_2O_3) of Thakoor is described by Thakoor as being hygroscopic. A "hygroscopic" is something that attracts water. Cr_2O_3 is a solid. A dielectric does not "attract" water. In fact, if a dielectric did attract water, the water itself would damage the nanoconductors disposed in the dielectric medium along with Applicant's chip itself, so it would not make sense to use a "hygroscopic" material such as that of Thakoor. The hygroscopic chromium trioxide (Cr_2O_3) of Thakoor tends to attract water, which could actually damage Applicant's nanoconductors and/or chip surface because when chromium trioxide is mixed with water it forms a strong acid. Note also that by adding more water to chromium trioxide, more hydrogen ions will be produced, which makes a for a good hydrogen ion source, but will also make for a very strong acid.

Such an acid will corrode and damage Applicant's nanoconductors (e.g., DNA, carbon nanotubes, gold nanowires, etc). Thus, it would not make sense to incorporate chromium trioxide into a device such as Applicant's invention that utilizes such nanoconductors because the nanoconductors, when in contact with the

acid will become damaged. The use of chromium trioxide clearly does not necessarily lead to the use of the dielectric medium of Applicant's invention.

Additionally, it is important to note that use of H+ions and the thin film of hygroscopic chromium trioxide in order to achieve the memistor of Thakoor is electrolytic in nature. Thakoor clearly states that the thin film of hygroscopic chromium trioxide (Cr_2O_3) serves as a hydrogen ion source (see Page 3132, paragraph under heading "Experimental Details" of Thakoor). The Thakoor device is thus based on an electrolytic configuration, that is, the use of an electrolyte and not a dielectric. Thakoor, for examples, at page 3133, second column, third paragraph, specifically refers to the use of an electrolyte. The memistor of Thakoor is based on the use of the electrochemical process of electrolysis, which is the production of chemical changes by the passage of current through an electrolyte (not a dielectric).

An example of such an electrochemical process is described in the "Introduction" section of Thakoor, Page 3132, Column 1, lines 34 to Column 2, line 2, where Thakoor states that "...in this paper, we report on the operational characteristics and application potential of a solid-state 'memistor," an analog memory device based on the electrochemical ion transport to/from tungsten oxide in a thin-films structure. The three-terminal devices utilizes a reversible transfer of metal (hydrogen) ions in tungsten oxide..." The use of electrolytes is taught, for example, on page 3133, column 1, lines 24-26 of Thakoor where Thakoor refers to "WO_3/electrolyte display". The memistor of Thakoor is based on the production of chemical changes by the passage of current through an electrolyte.

An electrolyte is a substance containing free ions which behaves as an electrically conductive medium unlike a dielectric, which is an electrical insulator, i.e., a substance that is highly resistant to electric current. Electrolytes are generally composed of ions in a solution of some sort. The use of free ions for a substance that behaves as electrically conductive medium, differs from that of a

dielectric, which tends to concentrate an applied electric field (e-field) within itself. This is a fundamental and key difference between Thakoor and Applicant's invention. Unlike an electrolyte, such as that employed by Thakoor, as a dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. This is not true of electrolytic materials such as that used to create the memistor of Thakoor. This also not true of the hygroscopic chromium trioxide (Cr_2O_3) material of Thakoor, which is not used by Thakoor as a dielectric but is used as a hydrogen ion source.

Thus, to summarize, Thakoor's device is based on the use of electrolytes and a material (Cr_2O_3) that is not used as a dielectric but is instead used as a hydrogen ion source. The hygroscopic chromium trioxide (Cr_2O_3) of Thakoor tends to attract water, which would actually damage the nanoconductors as indicated previously.

Based on the foregoing, it can be appreciated from a strict prima facie anticipation standpoint, Thakoor does not disclose the use of a dielectric medium taught by Applicant's invention. From an inherency-based anticipation standpoint, it is also clear that Thakoor does not inherently anticipate Applicant's use of the dielectric medium. That is, based on the requirements of establishing inherency as a basis for anticipation, the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor does not inherently anticipate the use of the dielectric by of Applicant's invention, because in relying upon the theory of inherency, the Examiner has not provided a basis in fact and/or technical reasoning to reasonably supporting the determination that the allegedly inherent characteristic of the use of a dielectric medium in which nanoconductors are free to move about necessarily flows from the teachings of the Thakoor reference.

Regarding the issue of neural connections formed between pre-synaptic and post-synaptic components of the physical neural network, the Examiner cited page 3132, left column, lines 24-41 of Thakoor. The Examiner has cited page 3132, left

column, lines 24-41 of Thakoor but has not identified, which specific components of Thakoor constitute pre-synaptic and post-synaptic components. Again, the Examiner has cited a general discussion of neural network components but has not actually cited where and how Thakoor specifically discloses a physical neural network and also pre-synaptic and post-synaptic components of a physical neural network. FIG. 3 of Thakoor, for example, is not a physical neural network. There is not even a synapse shown in FIG. 3 of Thakoor. Rather, what is shown is an autonulling neural node void of synapses. There are thus not even pre-synaptic and post-synaptic terminals in FIG. 3 of Thakoor. The Applicant cannot find any where in Thakoor where pre-synaptic and post-synaptic terminals are present, particularly given the fact that the memistor of Thakoor is a three-terminal device and a device containing pre- and post-synaptic terminals necessarily requires only two electrodes (i.e., one input and one output).

Regarding the issue of a learning mechanism for Hebbian learning, the Examiner cited page 3133, left column, lines 1-14, which states the following:

> "...electrodes, the electric field drive H+ ions from the Cr2O3 toward the cathode WO3. The injection of H+ ions (protons) into the WO3 (insulating) layer results in the formation of conducting HxWO3 (tungstic acid). The rate of formation of HxWO3 depends primarily on the control voltage. The above process can be reversed by an application of a negative control voltage (with respect to the read electrodes). In the reverse process, anodic dissociation of HxWO3 proceeds with the liberation of hydrogen. The rate of dissociation can also e varied with the magnitude of the control voltage....the reistance of the devices was measured with the control electrode at ground potential and a small voltage (~ 100 milivolts) applied across the read electrodes".

How is this <u>learning</u>? How is a <u>learning</u> mechanism? How does the foregoing description cited by the Examiner constitute <u>Hebbian</u> learning? To one of ordinary skill in the art, Thakoor on page 3133, left column, lines 1-14, provides no hint, teaching or disclosure of "Hebbian Learning". In fact, Thakoor on page 3133, left column, lines 1-14 also does not clearly provide for a teaching of any <u>learning</u> mechanism. Learning does not constitute programming the device. Thakoor on page 3133, left column, lines 1-14 merely describes the electrochemical process

involved for programming the memistor of Thakoor. This does not describe learning or adaptability because in order for the internal state of the Thakoor memistor to change, a voltage must be provided on the gate electrode. This voltage can only come from an external circuit. Therefore the description on page 3133, left column, lines 1-14 of Thakoor cited by the Examiner as a basis for "learning" could not possibly learn without the addition or help of an external circuit. Page 3133, left column, lines 1-14 merely describes the rate of disassociation of hydrogen ions in the context of a controlled voltage for programming the memistor. It should be pointed out that the word "control" implies a controller, which is not detailed in the description and required for learning. The Applicant's invention on the other hand, can adapt in the absence of a control circuit. Thakoor thus provides no basis for learning, let alone Hebbian learning.

Applicant's Hebbian learning mechanism must operate in a very specific manner in order to provide for Hebbian learning. In order to understand what Hebbian learning is, the Applicant believes it would be helpful to provide a brief overview of Hebbian learning.

Hebbian learning is based on Hebbian theory, which describes a basic mechanism for synaptic plasticity wherein an increase in synaptic efficacy arises from the presynaptic cell's *repeated* and *persistent* stimulation of the postsynaptic cell. Introduced by Donald Hebb in 1949, it is also called Hebb's rule and is referred to as Hebbian learning as well.

From the point of view of artificial neurons and artificial neural networks, Hebb's principle can be described as a method of determining how to alter the weights between model neurons as a function of their correlations of their activity in time. The weight between two neurons will increase if the two neurons activate simultaneously (they are correlated); it is reduced if they activate separately. Nodes which tend to be either both positive or both negative at the same time will have strong positive weights while those which tend to be opposite will have strong

negative weights. It is sometimes stated more simply as "neurons that fire together, wire together."

This original principle is perhaps the simplest form of weight selection. While this means it can be relatively easily coded into a computer program and used to update the weights for a network, it also prohibits the number of applications of Hebbian learning, at least with respect to software simulations of neural networks. This is because large neural networks contain massive numbers of synapses and the modification of the synapse in the traditional computing paradigm requires accessing memory. This memory access requires extraordinarily more energy than a physical neural network where synaptic states do not have to be "accessed". Today, the term *Hebbian learning* generally refers to some form of mathematical abstraction of the original principle proposed by Hebb. In this sense, Hebbian learning involves weights between learning nodes being adjusted so that each weight better represents the relationship between the nodes. As such, many learning methods can be considered to be somewhat Hebbian in nature.

The following is a formulaic description of Hebbian learning: (note that many other descriptions are possible)

$$w_{ij} = x_i x_j$$

where w_{ij} is the weight of the connection from neuron j to neuron i and x_i the input for neuron i. Note that this is pattern learning (weights updated after every training example). In a Hopfield network, connections w_{ij} are set to zero if $i = j$ (no reflexive connections allowed). With binary neurons (activations either 0 or 1), connections would be set to 1 if the connected neurons have the same activation for a pattern.

Another formulaic description is:

$$w_{ij} = \frac{1}{n} \sum_{k=1}^{p} x_i^k x_j^k ,$$

where w_{ij} is the weight of the connection from neuron j to neuron i, n is the dimension of the input vector, p the number of training patterns, and x_i^k the kth input for neuron i. The Applicant invites the Examiner to view the following web site, which contains a good general overview of Hebbian learning:

http://en.wikipedia.org/wiki/Hebbian_learning

Based on a review of Thakoor and a basic understanding of what constitutes "learning" and specifically, Hebbian learning, it is very clear that Thakoor does not provide for <u>any</u> teaching, suggestion or disclosure of Hebbian learning. Additionally, it is very clear that Thakoor does <u>not</u> inherently anticipate Hebbian learning, and thus the Hebbian learning mechanism provided by Applicant's invention. The Examiner has not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory". Hebbian learning does not necessarily flow from page 3133, left column, lines 1-14 of Thakoor as the Examiner argues.

Based on the foregoing, the Applicant submits that the rejection to claim 1 under 35 U.S.C. 102 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 1.

Regarding claim 2, the Examiner argued that Thakoor teaches the system of claim 1 wherein said learning mechanism utilizes a voltage gradient to implement Hebbian plasticity within said physical neural network (the Examiner cited Thakoor, Figure 2 in support of this argument). The Applicant notes that the arguments presented above against the rejection to claim 1 also apply equally to the rejection to claim 2 because claim 2 depends from claim 1.

FIG. 2 of Thakoor does not teach, suggest or disclose a learning mechanism, and specifically provides no teaching, suggestion or disclosure of Hebbian plasticity.

The Examiner has stated Thakoor utilizes a voltage gradient to implement Hebbian plasticity. However, there is no teaching in Thakoor of plasticity let alone a complicated neural process such as Hebbian plasticity. "Plasticity" is not simply the ability to develop or adapt in response to an environment, or the ability to learn or unlearn. This is an oversimplification of a concept that is inherently much more complex and sophisticated.

FIG. 2 of Thakoor is simply a plot of resistance versus time for several control voltages for a turning the memistor device of Thakoor "on" and "off". FIG. 2 does not suggest, disclose or teach any sort of "learning" or "unlearning". FIG. 2 merely describes "turn-on" and "turn-off" characteristics of the Thakoor device, and does not illustrate a device that has the ability to develop or adapt in response to its environment. FIG. 2 of Thakoor merely shows two plots, one describing the turn-on programming voltage and another plot that describes a turn off programming voltage. For example, page 3133, left column 3rd paragraph of Thakoor merely describes the turn-on and turn-off characteristics of memistor with respect to the FIG. 2 illustration.

The Examiner's arguments with respect to FIG. 2 of Thakoor do not adequately explain how one skilled in the art would identify FIG. 2 as illustrating plasticity and more importantly, Hebbian plasticity or anti-Hebbian plasticity and/or the performance of any sort of "learning" or "unlearning". The word "Hebbian" does not actually appear anywhere in the Thakoor reference. "Hebbian" plasticity is not even implied anywhere in Thakoor. In order to demonstrate Hebbian plasticity by Thakoor, it would be necessary to show how correlations or anti-correlations in voltage signals on the Ni electrodes in FIG. 1 of Thakoor result in a conductance increase or decrease. This is not demonstrated by FIG. 2 of Thakoor and in fact is demonstrated at all anywhere in Thakoor. FIG. 2 of Thakoor provides disclosure, hint or teaching of Hebbian plasticity.

Based on the foregoing, the Applicant submits that there is simply not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian plasticity or anti-Hebbian plasticity flows from the teachings from the test device programming characteristics for variations in resistance of test device with time for several different control voltages of Thakoor's FIG. 2. Plasticity and Hebbian plasticity in particular are very specific types of neural network features, and there is clearly not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian plasticity <u>necessarily</u> flows from the teachings from Thakoor. Thus, FIG. 2 of Thakoor does not inherently anticipate Hebbian and/or anti-Hebbian plasticity, or learning/unlearning and not even plasticity.

Based on the foregoing, the Applicant submits that the rejection to claim 2 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 2 under 35 U.S.C. 102.

Regarding claim 3, the Examiner argued that Thakoor teaches the system of claim 1 wherein said learning mechanism utilizes voltage gradient dependencies associated with physical neural network to implement Hebbian learning within said physical neural network (the Examiner cited Thakoor, Figure 2 in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 1 apply equally to the rejection to claim 3 because claim 3 depends from claim 1.

Again, as indicated earlier, Thakoor does not disclose, teach or suggest Hebbian learning and Hebbian learning does not necessarily flow from the teachings of Thakoor. Furthermore, Figure 2 of Thakoor does not describe a learning mechanism as taught by Applicant's invention, and also does not provide for any teaching whatsoever of "Hebbian learning" as taught by Applicant's invention. Instead, Figure 2 of Thakoor only illustrates a graph of resistance versus time (in minutes), and <u>programming</u> characteristics based on resistance versus time with

respect to various voltages. The Examiner argued that FIG. 2 of Thakoor utilizes voltage gradient dependencies to somehow provide for a teaching of Hebbian leaning (by citing FIG. 2 of Thakoor). It might be helpful to the Examiner to make the distinction between a voltage gradient and a voltage. A gradient is a spatial derivative, which means that a voltage gradient is how much the voltage changes across a distance. This is not equivalent to voltage. By referencing FIG. 2 as an example of a voltage gradient dependence is like saying that the slope of a mountain is equal to its height. FIG. 2 clearly states the resistance of the Thakoor memistor is dependent on voltage, not voltage gradient.

FIG. 2 is thus not a learning mechanism or Hebbian learning as taught by Applicant's claim 3. FIG. 2 merely demonstrates that the memistor can achieve device programmability over a wide range of resistances, but not actual learning. FIG. 2 relates to the ability of the memistor to exhibit electrochemical analog memory effects, but not actual learning and clearly not plasticity or Hebbian plasticity. In fact, Thakoor specifically states that the memistor is an analog memory device. The memistor is simply a reprogrammable resistor with memory, but is not a learning device. The memistor is thus a device for storing data, and not a device that learns or exhibits Hebbian plasticity. The memistor also has characteristics of resistor but again does not exhibit Hebbian plasticity. For example, page 3132, left column, lines 38-39 specifically note that the memistor is a memory device.

Based on the foregoing, the Applicant submits that the rejection to claim 3 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 3 under 35 U.S.C. 102.

Regarding claim 4, the Examiner argued that Thakoor teaches the system of claim 1 wherein said learning mechanism utilizes pre-synaptic and post-synaptic frequencies to provide Hebbian learning within said physical neural network (the Examiner cited page 3132, left column, lines 24-41; and page 3133, left column,

lines 1-14 in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 1 apply equally against the rejection to claim 4.

Page 3132, left column, lines 24-41 describes generally how in electronic implementations of neural networks, neurons can be modeled as thresholding nonlinear amplifiers and that synapses can function as resistive interconnects. Page 3132, left column, lines 24-41 also describes a memistor as being a reprogrammable resistor with memory, and hence an analog memory device. There is no teaching here, however, that the memistor of Thakoor possesses pre-synaptic and post-synaptic components or even functions as a neural network. There is also no mention here of pre-synaptic and post-synaptic frequencies. The word "frequency" does not even appear nor is implied at Page 3132, left column, lines 24-41 of Thakoor cited b the Examiner. Where is Hebbian learning even implied by Page 3132, left column, lines 24-41 of Thakoor? It is not clear how one skilled in the art would interpret Page 3132, left column, lines 24-41 to imply Hebbian learning? The same arguments apply essentially against page 3133, left column, lines 1-14. Based on the foregoing, the Applicant submits that the rejection to claim 4 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 4 under 35 U.S.C. 102.

Regarding claim 5, the Examiner argued that Thakoor teaches the system of claim 1 wherein said learning mechanism utilizes a voltage gradient to implement anti-Hebbian plasticity within said physical neural network (the Examiner cited Figure 2 of Thakoor in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 1 apply equally against the rejection to claim 5. <u>How</u> is the voltage gradient of Thakoor used to implement <u>anti-Hebbian</u> plasticity? How does <u>anti-Hebbian</u> plasticity necessarily flow from FIG. 2 of Thakoor?

The Applicant asks, how do the features of Thakoor the Examiner cited with respect to page 3133, left column, lines 1-14 constitute a "learning mechanism" and specifically anti-Hebbian learning. How and why are anti-Hebbian learning accomplished by "the growing or lessening the conductivity of the resistance put a field to adjust the memory" of Thakoor. Simply adjusting memory is not "anti-Hebbian learning". Anti-Hebbian learning is a much more sophisticated and complicated process, which is not achieved simply "adjusting memory". Additionally, and even more importantly, how does such a feature of Thakoor inherently anticipate <u>anti-Hebbian</u> learning?

To one of ordinary skill in the art, Thakoor on page 3133, left column, lines 1-14, provides no hint, teaching or disclosure of "anti-Hebbian Learning". In fact, Thakoor on page 3133, left column, lines 1-14 also does not clearly provide for a teaching of a <u>learning</u> mechanism. Applicant's <u>anti-Hebbian</u> learning mechanism must operate in a very specific manner in order to provide for <u>anti-Hebbian</u> learning. In order to understand what anti-Hebbian learning is, the Applicant believes it would be helpful for the Examiner to refer to the brief overview of Hebbian learning provided early. Hebbian learning is based on <u>Hebbian</u> theory, which describes a basic mechanism for synaptic plasticity wherein an increase in synaptic efficacy arises from the presynaptic cell's *repeated* and *persistent* stimulation of the postsynaptic cell. Hebbian theory and Hebbian learning is simply not anticipated inherently or otherwise anywhere within Thakoor. In general, Hebbian learning can thus be implemented in neural networks as a technique for modifying connection based on correlations in pre- and post-synaptic activity. Anti-Hebbian learning is essentially the opposite of Hebbian-based learning techniques. In anti-Hebbian learning, the connections are weakened when connections and/or neurons are correlated in activity, and strengthened when pre- and post-synaptic activity is anti-correlated. Such anti-Hebbian learning is not suggested, disclosed or taught by Thakoor no page 3133, left column, lines 1-14 cited by the Examiner.

Based on a review of Thakoor and a basic understanding of Hebbian learning it is very clear that Thakoor does not provide for any teaching, suggestion or disclosure of anti-Hebbian learning. Additionally, it is very clear that Thakoor does not inherently anticipate anti-Hebbian learning, and thus the Hebbian learning mechanism provided by Applicant's invention. The Examiner has not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of anti-Hebbian plasticity <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory"

Thus, from a prima facie anticipation standpoint, Thakoor provides no disclosure of anti-Hebbian learning (or Hebbian learning for that matter). From an inherency-based anticipation standpoint, anti-Hebbian learning clearly does not necessarily flow form the teachings of Thakoor and thus Thakoor does not inherently anticipate the anti-Hebbian plasticity of Applicant's invention.

Based on the foregoing, the Applicant submits that the rejection to claim 5 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 5 under 35 U.S.C. 102.

Regarding claim 6, the Examiner argued that Thakoor teaches the system of claim 1 wherein said learning mechanism utilizes voltage gradient dependencies associated with the physical neural network to implement anti-Hebbian learning within the physical neural network (the Examiner cited Figure 2 of Thakoor in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 1 apply equally against the rejection to claim 6. Figure 2 of Thakoor does not provide for any teaching of <u>anti-Hebbian plasticity</u>. The Examiner has not identified how voltage gradient dependencies bring about anti-Hebbian plasticity,

particularly when there is not even a mention of plasticity or anti-Hebbian plasticity anywhere within Thakoor.

Instead, Figure 2 of Thakoor only illustrates a graph of resistance versus time (in minutes), and programming characteristics based on resistance versus time with respect to various voltages. This is not anti-Hebbian plasticity as taught by Applicant's claim 6. Based on the foregoing, the Applicant submits that the rejection to claim 6 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 6 under 35 U.S.C. 102.

Regarding claim 7, the Examiner argued that Thakoor teaches the system of claim 1 wherein said learning mechanism utilizes pre-synaptic and post-synaptic frequencies to provide anti-Hebbian learning within said physical neural network (the Examiner cited page 3132, left column, lines 24-41; and page 3133, left column, lines 1-14 in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 1 apply equally against the rejection to claim 7. Also, the arguments that the Applicant presented above earlier with respect to age 3132, left column, lines 24-41; and page 3133, left column, lines 1-14 apply equally against claim 7. Page 3132, left column, lines 24-41 generally describes the reprogrammable resistor with memory, i.e., a memistor. There is no teaching or disclosure at page 3132, left column, lines 24-41 of pre-synaptic frequencies or post-synaptic frequencies. There is also no teaching or disclosure at page 3132, left column, lines 24-41 of anti-Hebbian learning. The Examiner has merely cited page 3132, left column 24-41 of Thakoor without specifically pointing out which features here anticipate pre-synaptic and post-synaptic frequencies and anti-Hebbian learning and how such pre-synaptic and post-synaptic frequencies provide for anti-Hebbian learning.

With regard to inherency-based anticipation, the Applicant reminds the Examiner that it is incumbent upon the Examiner to point to the page and line of

the prior art that justifies the rejection based on an inherency theory. The Examiner must not leave the Applicant to guess at the basis of the inherency rejection. Additionally, the fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. In this case, the Applicant is left guessing as to which features of page 3132, left column 24-41 of Thakoor constitute pre-synaptic and post-synaptic frequencies and anti-Hebbian learning. Additionally, simply because page 3132, left column 24-41 of Thakoor mentions neural network architectures and neurons and synapses does is not sufficient to establish inherency with respect to pre-synaptic and post-synaptic frequencies and anti-Hebbian learning.

Regarding page 3133, left column, lines 1-14 cited by the Examiner, again the Applicant notes that is clearly no teaching or disclosure here of pre-synaptic frequencies or post-synaptic frequencies or anti-Hebbian learning. The Examiner has merely cited page 3133, left column, lines 1-14 of Thakoor without specifically pointing out which features here anticipate pre-synaptic and post-synaptic frequencies and anti-Hebbian learning and how such pre-synaptic and post-synaptic frequencies provide for anti-Hebbian learning.

With regard to inherency-based anticipation, the Applicant reminds the Examiner that it is incumbent upon the Examiner to point to the page and line of the prior art that justifies the rejection based on an inherency theory. The Examiner must not leave the Applicant to guess at the basis of the inherency rejection. Additionally, the fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. In this case, the Applicant is left guessing as to which features of 3133, left column, lines 1-14 of Thakoor constitute pre-synaptic and post-synaptic frequencies and anti-Hebbian learning.

Based on the foregoing, the Applicant submits that the rejection to claim 7 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 7 under 35 U.S.C. 102.

Regarding claim 9, the Examiner argued that Thakoor teaches the system of claim 1 wherein said plurality of nanoconductors includes nanoconductors comprising nanowires (the Examiner cited page 3133, left column, lines 4-5 of Thakoor in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 1 apply equally against the rejection to claim 9. Page 3133, left column, lines 4-5 of Thakoor does not teach, disclose or suggest "nanowires" as taught by Applicant's claim 9. Instead, page 3133, left column, lines 4-5 of Thakoor indicates only that "the rate of formation of H_xWO_3 depends primarily on the control voltage". H_xWO_3 is a chemical compound, but <u>not</u> a nanowire as taught by Applicant's claim 9.

H_xWO_3 is simply a chemical compound and is not a nanowire. A nanowire by definition is a much more complicated and versatile device than the chemical compound of H_xWO_3. In order to understand what a nanowire is, the Applicant believes it would be helpful for the Examiner to review the information about nanowires freely available at the following web site:

http://en.wikipedia.org/wiki/Nanowire

The first thing to appreciate about a nanowire is that it is a <u>wire</u>. The H_xWO_3 of Thakoor is not a wire. A nanowire is a <u>wire</u> of dimensions of the order of a nanometer (10^{-9} meters). Alternatively, nanowires can be defined as structures that have a lateral size constrained to tens of nanometers or less and an unconstrained longitudinal size. At these scales, quantum mechanical effects are important — hence such wires are also known as "quantum wires". Many different types of nanowires exist, including metallic (e.g., Ni, Pt, Au), semiconducting (e.g., InP, Si, GaN, etc.), and insulating (e.g., SiO_2,TiO_2). Molecular nanowires are

composed of repeating molecular units either organic (e.g. DNA) or inorganic (e.g. $Mo_6S_{9-x}I_x$).

Typical nanowires exhibit aspect ratios (the ratio between length to width) of 1000 or more, but this value may vary. As such they are often referred to as 1-Dimensional materials. Nanowires have many interesting properties that are not seen in bulk or 3-D materials. This is because electrons in nanowires are quantum confined laterally and thus occupy energy levels that are different from the traditional continuum of energy levels or bands found in bulk materials. Peculiar features of this quantum confinement exhibited by certain nanowires such as carbon nanotubes manifest themselves in discrete values of the electrical conductance. Such discrete values arise from a quantum mechanical restraint on the number of electrons that can travel through the wire at the nanometer scale. These discrete values are often referred to as the quantum of conductance and are integer values of $\frac{2e^2}{h} \approx 12.9\ k\Omega^{-1}$. They are inverse of the well-known resistance unit h/e^2, which is roughly equal to 25812.8 ohms, and referred to as the von Klitzing constant R_K (after Klaus von Klitzing, the discoverer of exact quantization). Since 1990, a fixed conventional value R_{K-90} is accepted.

Examples of nanowires include inorganic molecular nanowires ($Mo_6S_{9-x}I_x$), which have a diameter of 0.9 nm, and can be hundreds of micrometers long. Other important examples are based on semiconductors such as InP, Si, GaN, etc., dielectrics (e.g. SiO_2,TiO_2), or metals (e.g. Ni, Pt).

The H_xWO_3 material of Thakoor is therefore not a nanowire as known in the art. FIG. 1 of Thakoor and page 3132-3133 of Thakoor makes it clear that the WO_3 of Thakoor is not a wire but merely a layer of the memistor device. The H_xWO_3 compound of Thakoor is the result of a chemical reaction wherein an influx of H+ ions react with the WO_3 layer to form the H_xWO_3 compound. On the contrary, the nanowires of Applicant's invention are prepared in a dielectric medium and do not

occur as a result of a chemical reaction. Applicant's nanowires are pre-disposed in a dielectric medium rather than as a result of a chemical reaction as part of the process of forming the memistor device. It is also significant to note that H_xWO_3 is tungstic acid (see page 3133, left column, line 4 of Thakoor). Mixing tungstic acid with Applicant's dielectric medium does not make sense because the acid would destroy the viability of the dielectric medium.

The H_xWO_3 compound (i.e., Tungstic Acid) of Thakoor simply does not inherently or directly anticipate the nanowires of Applicant's invention. The Examiner has simply not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of a nanowire flows from the teachings from the H_xWO_3 compound of Thakoor. Thus, the H_xWO_3 compound (i.e., Tungstic Acid) of Thakoor does not anticipate the nanowires of Applicant's invention. Based on the foregoing, the Applicant submits that the rejection to claim 9 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 9 under 35 U.S.C. 102.

Regarding claim 10, the Examiner argued that Thakoor teaches the system of claim 1 wherein said plurality of nanoconductors includes nanoconductors comprising nanoparticles (the Examiner cited page 3133, left column, lines 4-5 in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 1 apply equally against the rejection to claim 10. Page 3133, left column, lines 4-5 of Thakoor does not teach, disclose or suggest "nanoparticles" as taught by Applicant's claim 10. Instead, page 3133, left column, lines 4-5 of Thakoor indicates only that "the rate of formation of H_xWO_3 depends primarily on the control voltage". H_xWO_3 is a chemical compound, but not a nanoparticle as taught by Applicant's claim 10. There is no disclosure here of nanoparticles as taught by Applicant's claim 10. Based on the foregoing, the Applicant submits that the

rejection to claim 10 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 10 under 35 U.S.C. 102.

Regarding claim 11, the Examiner argued that Thakoor teaches a system, comprising:

a physical neural network configured utilizing nanotechnology (the Examiner cited "title" in support of this argument), wherein said physical neural network comprises a plurality of nanoconductors suspended and free to move about in a dielectric medium (citing page 3132, right column, lines 10-12; and page 3133, right column, lines 3-5) which form neural connections between pre-synaptic and post-synaptic components of said physical neural network (the Examiner cited page 3132, left column, lines 24-41 of Thakoor in support of this argument; and

a learning mechanism for applying Hebbian learning to said physical neural network wherein said learning mechanism utilizes a voltage gradient or pre-synaptic and post-synaptic frequencies thereof to implement Hebbian or anti-Hebbian plasticity within said physical neural network (the Examiner cited page 3133, left column, lines 1-14 of Thakoor in support of this argument).

The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claims 1, 6, 7 apply equally to the rejection to claim 11. In the interest of brevity, the Applicant will not repeat these arguments. The Applicant notes again, based on the arguments presented earlier, that there is no anticipation, inherent or otherwise, of the use of Applicant's dielectric medium, nanoconductors (e.g., DNA, nanowires, nanotubes, etc) free to move about in the dielectric medium, nanotechnology, physical neural network, pre-synaptic and post-synaptic components, Hebbian learning, a learning mechanism, the use of a voltage gradient or pre-synaptic and post-synaptic frequencies to implement Hebbian/anti-Hebbian plasticity and so forth.

Based on the foregoing, the Applicant submits that the rejection to claim 11 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 11 under 35 U.S.C. 102.

Regarding claim 13, the Examiner argued that Thakoor teaches the system of claim 11 wherein said plurality of nanoconductors includes nanoconductors comprising nanowires (the Examiner cited page 3133, left column, lines 4-5 in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 11 apply equally against the rejection to claim 13. The Applicant also submits that the arguments presented above against the rejection to claims 1 and 9 apply equally to the rejection to claim 13. As such, Thakoor does not anticipate, inherently or otherwise, the nanowires of Applicant's invention. Based on the foregoing, the Applicant submits that the rejection to claim 13 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 13 under 35 U.S.C. 102.

Regarding claim 14, the Examiner argued that Thakoor teaches the system of claim 11 wherein said plurality of nanoconductors includes nanoconductors comprising nanoparticles (the Examiner cited page 3133, left column, lines 4-5 in support of this argument). The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 11 apply equally against the rejection to claim 14. The Applicant also submits that the arguments presented above against the rejection to claims 1 and 10 apply equally against the rejection to claim 14. As such, Thakoor does not anticipate, inherently or otherwise, the nanoparticles of Applicant's invention. Based on the foregoing, the Applicant submits that the rejection to claim 14 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 14 under 35 U.S.C. 102. Based on the foregoing, the Applicant submits that the

rejection to claim 14 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 14 under 35 U.S.C. 102.

Regarding claim 15, the Examiner argued that Thakoor teaches the system of claim 11 wherein said dielectric medium comprises a dielectric liquid. The Applicant cited page 3132, right column, lines 10-12; and page 3133, right column, lines 3-5 in support of this argument.

Page 3132, right column, lines 10-12 indicates that "a thin film of hygroscopic chromium trioxide (Cr_2O_3) serving as a hydrogen ion source is deposited by reactive magnetron sputtering".

Page 3133, right column, lines 3-5 indicates that "...since the Cr_2O_3 film serves as a source of H+ions, its ability to absorb and retain water is crucial to the device operation".

The Examiner is therefore asserting that chromium trioxide (Cr_2O_3) is used as a dielectric liquid. This is simply not the case. Again, as indicated previously, the Cr_2O_3 of Thakoor constitutes a hydrogen <u>ion source</u> and not a <u>dielectric</u> <u>liquid</u>. Chromium trioxide (Cr_2O_3) is also a solid and not a liquid. (Recall that the device of memistor is a solid-state device, i.e., see title of Thakoor, and not a liquid-state device). In order to appreciate why the chromium trioxide of Thakoor is not used as a dielectric, the Applicant believes it would be helpful to discuss what a dielectric is and is not and also analyze some of the properties inherent to chromium trioxide.

A dielectric is a material that tends to concentrate an applied electric field (e-field) within itself. As the dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. The chromium trioxide (Cr_2O_3) of Thakoor is hygroscopic as Thakoor clearly states. A "hygroscopic" is something that attracts water. However, as indicated previously and is well known in the chemical arts, Cr_2O_3 is a solid. Thakoor also indicates that that the memistor of Thakoor is a "solid-state" device.

See, for example, the title of Thakoor: "Solid-State thin-film memistor, etc." Additionally, simply because something attracts water does not make it a liquid such as the dielectric liquid taught by Applicant's invention. Cr_2O_3 in its hygroscopic form can attract water, but Cr_2O_3 remains a solid.

A dielectric, on the other hand, does not "attract" water. In fact, if a dielectric did attract water the water itself would damage Applicant's dielectric liquid and the plurality of nanoconductors disposed in the dielectric liquid, so it would not make sense to use a "hygroscopic" material such as that of Thakoor. Also, chromium trioxide (Cr_2O_3) does not tend to concentrate an applied electric field within itself and does not interact with the applied electric field so that charges are redistributed within atoms or molecules of the Cr_2O_3 compound. It is also important to note that chromium trioxide, when combined with water, forms a strong acid, also known as chromic acid. An acid would tend to corrode Applicant's nanoconductors such as DNA, carbon nanotubes, gold nanowires, etc and thus it would not make sense to incorporate chromium trioxide into a device that utilizes such nanoconductors because the nanoconductors, when in contact with the chromium trioxide will become damaged.

Additionally, it is important to note that use of H+ions and the thin film of hygroscopic chromium trioxide in order to achieve the memistor of Thakoor is electrolytic in nature. Thakoor clearly states that the thin film of hygroscopic chromium trioxide (Cr_2O_3) serves as a hydrogen ion source (see Page 3132, paragraph under heading "Experimental Details" of Thakoor). The Thakoor device is thus based on an electrolytic configuration, that is, the use of an electrolyte and not a dielectric. Thakoor, for examples, at page 3133, second column, third paragraph, specifically refers to the use of an electrolyte. The memistor of Thakoor is based on the use of the electrochemical process of electrolysis, which is the production of chemical changes by the passage of current through an <u>electrolyte</u> (not a dielectric).

An example of such an electrochemical process is described in the "Introduction" section of Thakoor, Page 3132, Column 1, lines 34 to Column 2, line 2, where Thakoor states that "...in this paper, we report on the operational characteristics and application potential of a solid-state 'memistor," an analog memory device based on the electrochemical ion transport to/from tungsten oxide in a thin-films structure. The three-terminal devices utilizes a reversible transfer of metal (hydrogen) ions in tungsten oxide..." The use of <u>electrolytes</u> is taught, for example on page 3133, column 1, lines 24-26 of Thakoor where Thakoor refers to "WO_3/<u>electrolyte</u> display". The memistor of Thakoor is based on the production of chemical changes by the passage of current through an <u>electrolyte</u>.

An electrolyte is a substance containing free <u>ions</u> which behaves as an electrically conductive medium. Electrolytes are generally composed of ions in a solution of some sort. The use of free ions for a substance that behaves as electrically conductive medium, differs from that of the use of a <u>dielectric</u>, which tends to concentrate an applied electric field within itself. This is a fundamental and key difference between Thakoor and Applicant's invention. Unlike an electrolyte, such as that employed by Thakoor, as a <u>dielectric</u> interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the <u>dielectric</u> material. This is <u>not</u> true of electrolytic materials such as that used to create the memistor of Thakoor. This also not true of the hygroscopic chromium trioxide (Cr_2O_3) material of Thakoor.

Thus, to summarize, Thakoor's device is based on the use of electrolytes, whereas Applicant's device is based on the use of a dielectric. Also, Applicant's claim 15 specifically refers to the use of a "dielectric liquid". Again, Cr_2O_3 is a solid. Per the requirements of claim 15, Applicant's nanoconductors (e.g., nanotubes, nanowires, DNA, etc) are disposed in the dielectric liquid and free to move about in

the dielectric liquid solution. Such nanoconductors could not possibly be free to move about in a solid such as Cr_2O_3. This is physically impossible.

Based on the foregoing, it can be appreciated from a strict prima facie anticipation standpoint, Thakoor does not disclose the dielectric liquid taught by Applicant's invention. From an inherency-based anticipation standpoint, it is also clear that Thakoor does not inherently anticipate Applicant's dielectric liquid. That is, based on the requirements of establishing inherency as a basis for anticipation, the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor does not inherently anticipate the dielectric liquid of Applicant's invention, because in relying upon the theory of inherency, the Examiner has not provided a basis in fact and/or technical reasoning to reasonably supporting the determination that the allegedly inherent characteristic of the use of a dielectric liquid in which Applicant's nanoconductors are free to move about <u>necessarily</u> flows from the teachings of the Thakoor reference. One skilled in the art would clearly not see the chromium trioxide of Thakoor as teaching the dielectric liquid of Applicant's invention. The evidence provided above proves the opposite.

Based on the foregoing, the Applicant submits that the rejection to claim 15 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 15 under 35 U.S.C. 102.

Regarding claim 16, the Examiner argued that Thakoor teaches the system of claim 15 wherein said plurality of nanoconductors form physical neural connections when said dielectric medium is exposed an electric field, such that said physical neural connections can be strengthened or weakened depending upon a strengthening or weakening of said electric field or an alteration of a frequency thereof (the Examiner cited page 3133, left column, lines 1-14 in support of this argument). The Applicant respectfully disagrees with this assessment and notes that all of the arguments presented above against the rejection to claim 15 apply equally against the rejection to claim 16.

Page 3133, left column, lines 1-14 of Thakoor does not disclose all of the following claim limitations of Applicant's claim 16: nanoconductors that form physical neural connections, the dielectric medium exposed to an electric field, and physical neural connections that can be strengthened or weakened depending upon a strengthening or weakening of said electric field or an alteration of a frequency thereof. Instead, page 3133, left column, lines 1-14 of Thakoor refers generally to "an electric field that drives H^+ ions from Cr_2O_3 toward the cathodic WO_3" and to the "injection of H+ ions (protons)" and so forth, but does not provide for a disclosure and/or teaching of nanoconductors disposed within a dielectric medium used for creating a physical neural network. There is also no disclosure here of neural connections and the strengthening or weakening of such neural connections. As indicated earlier, Thakoor also does not disclose, suggest and/or teach nanoconductors as taught by Applicant's invention. Based on the foregoing, the Applicant submits that the rejection to claim 16 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 16 under 35 U.S.C. 102.

Regarding claim 17, the Examiner argued that Thakoor teaches a system, comprising:

a plurality of molecular conductors disposed within a dielectric medium comprising a dielectric solvent or a dielectric solution (the Examiner cited page 3133, left column, lines 1-14 in support of this argument);

at least one input electrode in contact with said dielectric medium (the Examiner cited page 3133, left column, lines 1-14 in support of this argument); and

at least one output electrode in contact with said dielectric medium, wherein said plurality of molecular conductors form physical neural connections when said dielectric medium is exposed an electric field across said at least one input electrode and said at least one output electrode, such that said physical neural connections can be strengthened or weakened depending upon a strengthening or weakening of said electric field or an alteration of a frequency thereof (the Examiner cited page

3132, left column, lines 24-41; and page 3133, left column, lines 1-14 in support of this argument).

The Applicant respectfully disagrees with this assessment and submits that the arguments presented above by the Applicant against the rejection to claims 1-16 apply equally against the rejection to claim 17. Page 3133, left column, lines 1-14 of Thakoor does not disclose the use of a "dielectric medium comprising a dielectric solvent or a dielectric solution" as taught by Applicant's amended clam 17, and in which nanoconductors (e.g., nanotubes, nanowires, DNA, etc.) are free to move about in the dielectric medium. As indicated previously, Thakoor simply does not provide for a teaching, disclosure or suggestion of the use of dielectric in which nanoconductors such as nanowires, nanotubes, DNA, etc are disposed and free to move about in order to form neural network connections.

Regarding the chromium trioxide of Thakoor, which the Examiner argues is used as a dielectric medium, the Applicant notes that one of the claim limitations of Applicant's claim 17 is "at least one output electrode in contact with the dielectric medium". FIG. 1 of Thakoor indicates that the chromium trioxide of Thakoor (i.e., the H+ ion source of Thakoor) is not in contact with at least one output electrode but is instead positioned between SiO layers. The electrodes of Thakoor are actually disposed well below the chromium trioxide layer of Thakoor. Thus, the chromium trioxide layer of Thakoor is not in contact with an output electrode. Of course, as explained previously, the chromium trioxide of Thakoor is not a dielectric. Also, keep in mind that the memistor device of Thakoor is a three-terminal device and not a two-terminal device such as that of Applicant's invention, which is a significant difference between the two inventions. Additionally, as indicated previously the hygroscopic chromium trioxide attracts water and when combined with water can form an acid that is highly corrosive and which would damage Applicant's nanoconductors.

Additionally, on page 3132, left column, lines 24-41 and page 3133, left column, lines 1-14 there is no teaching, disclosure and/or suggestion of "exposing an electric field" across the dielectric medium in order to strengthen or weaken neural connections based on the strengthening or weakening of the electric field or the alternation of a frequency thereof. Again, 3132, left column, lines 24-41, refers only to the reprogrammable resistor with memory (memistor) but provides no hint of a dielectric medium or the strengthening/weakening of neural connections. Page 3133, left column, lines 1-14 also does not provide any hint or disclosure of a dielectric medium or the strengthening/weakening of neural connections.

Based on the foregoing, the Applicant submits that the rejection to claim 17 based on Thakoor has been traversed. The Applicant therefore respectfully requests withdrawal of the rejection to claim 17 under 35 U.S.C. 102.

Regarding claim 18, the Examiner argued that Thakoor teaches the system of claim 17 further comprising a physical neural network comprising said plurality of molecular conductors disposed within a dielectric medium comprising a dielectric solvent or a dielectric solution (citing page 3132, right column, lines 10-12), said at least one input electrode in contact with said dielectric medium, and said at least one output electrode in contact with said dielectric medium (the Examiner cited page 3133, left column, lines 1-14 of Thakoor in support of this argument). The Applicant respectfully disagrees with this assessment and notes that the arguments presented above against the rejection to claim 17 apply equally against the rejection to claim 18.

Page 3132, right column, lines 10-12 indicates that "a thin film of hygroscopic chromium trioxide (Cr_2O_3) serving as a hydrogen ion source is deposited by reactive magnetron sputtering".

Page 3133, left column, lines 1-14, states the following:

"...electrodes, the electric field drive H+ ions from the Cr2O3 toward the cathode WO3. The injection of H+ ions (protons) into the WO3 (insulating) layer

results in the formation of conducting HxWO3 (tungstic acid). The rate of formation of HxWO3 depends primarily on the control voltage. The above process can be reversed by an application of a negative control voltage (with respect to the read electrodes). In the reverse process, anodic dissociation of HxWO3 proceeds with the liberation of hydrogen. The rate of dissociation can also e varied with the magnitude of the control voltage....the reistance of the devices was measured with the control electrode at ground potential and a small voltage (~ 100 milivolts) applied across the read electrodes".

The Examiner is therefore asserting that chromium trioxide (Cr_2O_3) is used as a dielectric medium comprising a dielectric solvent or a dielectric solution. This is simply not the case. The Cr_2O_3 of Thakoor constitutes a hydrogen ion source and is not used as a dielectric medium comprising a dielectric solvent or a dielectric solution. In order to appreciate why the chromium trioxide of Thakoor is not used as a dielectric solvent or a dielectric solution, the Applicant believes it would be helpful to discuss what a dielectric is and is not and also analyze some of the properties inherent to chromium trioxide.

A dielectric is a material that tends to concentrate an applied electric field (e-field) within itself. As the dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. The chromium trioxide (Cr_2O_3) of Thakoor is hygroscopic as Thakoor clearly states. A "hygroscopic" is something that attracts water. Cr_2O_3 is also a solid. A dielectric does not "attract" water. In fact, if a dielectric did attract water the water itself would damage Applicant's dielectric medium and plurality of nanoconductors disposed in the dielectric medium, so it would not make sense to use a "hygroscopic" material such as that of Thakoor. Chromium trioxide (Cr_2O_3) does not tend to concentrate an applied electric field within itself and does not interact with the applied electric field so that charges are redistributed within atoms

or molecules of the dielectric. It is also important to note that as indicated previously, chromium trioxide when in contact with water (which is necessary for Thakoor to produce H+ ions) creates an acid, also known as chromic acid. An acid will corrode Applicant's nanoconductors such as DNA, carbon nanotubes, gold nanowires, etc and thus it would not make sense to incorporate chromium trioxide into a device that utilizes such nanoconductors because the nanoconductors, when in contact with the chromium trioxide will become damaged.

Additionally, it is important to note that use of H+ions and the thin film of hygroscopic chromium trioxide in order to achieve the memistor of Thakoor is electrolytic in nature. Thakoor clearly states that the thin film of hygroscopic chromium trioxide (Cr_2O_3) serves as a hydrogen ion source (see Page 3132, paragraph under heading "Experimental Details" of Thakoor). There is no evidence from Thakoor that the chromium trioxide is used as a dielectric medium in which nanoconductors (e.g., nanotubes, nanowires, DNA, etc) are free to move about in the dielectric medium. The Thakoor device is based on an electrolytic configuration, that is, the use of an electrolyte and not on the use of a dielectric to perform a particular process. Thakoor, for examples, at page 3133, second column, third paragraph, specifically refers to the use of an electrolyte. The memistor of Thakoor is based on the use of the electrochemical process of electrolysis, which is the production of chemical changes by the passage of current through an <u>electrolyte</u> (not a dielectric).

An example of such an electrochemical process is described in the "Introduction" section of Thakoor, Page 3132, Column 1, lines 34 to Column 2, line 2, where Thakoor states that "...in this paper, we report on the operational characteristics and application potential of a solid-state 'memistor," an analog memory device based on the electrochemical ion transport to/from tungsten oxide in a thin-films structure. The three-terminal devices utilizes a reversible transfer of metal (hydrogen) ions in tungsten oxide..." The use of <u>electrolytes</u> is taught, for

example on page 3133, column 1, lines 24-26 of Thakoor where Thakoor refers to "WO_3/electrolyte display". The memistor of Thakoor is based on the production of chemical changes by the passage of current through an electrolyte.

An electrolyte is a substance containing free ions which behaves as an electrically conductive medium. Electrolytes are generally composed of ions in a solution of some sort. The use of free ions for a substance that behaves as electrically conductive medium, differs from that of a dielectric, which tends to concentrate an applied electric field within itself. This is a fundamental and key difference between Thakoor and Applicant's invention. Unlike an electrolyte, such as that employed by Thakoor, as a dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. This is not true of electrolytic materials such as that used to create the memistor of Thakoor.

Thus, to summarize, Thakoor's device is based on the use of electrolytes, whereas Applicant's device is based on the use of a dielectric. Additionally, the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor is not a dielectric solvent or a dielectric solution and also tends to attract water, which will damage the dielectric configuration of Applicant's invention and when in acid form, will corrode Applicant's nanoconductors.

Based on the foregoing, it can be appreciated from a strict prima facie anticipation standpoint, Thakoor does not disclose the dielectric medium taught by Applicant's invention. From an inherency-based anticipation standpoint, it is also clear that Thakoor does not inherently anticipate the use of Applicant's dielectric medium comprising a dielectric solvent or a dielectric solution and one in which nanoconductors (as taught by Applicant) are disposed and free to move about. That is, based on the requirements of establishing inherency as a basis for anticipation, the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor does not

inherently anticipate the use of a dielectric medium (comprising a dielectric solvent or a dielectric solution) in which nanoconductors (e.g., DNA, nanowires, nanotubes) are to free to move about, because in relying upon the theory of inherency, the Examiner has not provided a basis in fact and/or technical reasoning to reasonably supporting the determination that the allegedly inherent characteristic of the use of a dielectric solvent or a dielectric solution as taught by Applicant's invention <u>necessarily</u> flows from the teachings of the Thakoor reference. One skilled in the art would clearly not see the chromium trioxide of Thakoor as teaching the use of a dielectric solvent or a dielectric solution of Applicant's invention. The evidence provided above proves the opposite.

Based on the foregoing, the Applicant submits that the rejection to claim 18 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 18 under 35 U.S.C. 102.

Regarding claim 19, the Examiner argued that Thakoor teaches the system of claim 18 further comprising a learning mechanism for applying Hebbian learning to said physical neural network wherein said learning mechanism utilizes a voltage gradient or pre-synaptic and post-synaptic frequencies thereof to implement Hebbian or anti-Hebbian plasticity within said physical neural network (the Examiner cited Figure 2 of Thakoor in support of this argument). The Applicant respectfully disagrees with this assessment and notes that the arguments presented above against the rejection to claim 18 apply equally against the rejection to claim 19.

The Applicant also submits that the arguments presented earlier by the Applicant regarding Hebbian and/or anti-Hebbian learning and/or plasticity apply equally against the rejection to claim 19. As such, Thakoor and particularly FIG. 2 of Thakoor do not anticipate, directly or inherently, Hebbian and anti-Hebbian plasticity and use of a voltage gradient or pre-synaptic or post-synaptic frequencies to implement Hebbian and anti-Hebbian plasticity.

Based on the foregoing, the Applicant submits that the rejection to claim 19 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 19 under 35 U.S.C. 102.

Regarding claim 20, the Examiner argued that Thakoor teaches the system of claim 18 wherein said physical neural network is configured as an integrated circuit chip utilizing nanotechnology (the Examiner cited Figure 3 of Thakoor in support of this argument). The Applicant respectfully disagrees with this assessment and notes that the arguments presented above against the rejection to claim 18 apply equally against the rejection to claim 20. The Applicant also submits that the arguments presented above against the rejection to claims 1-19 apply equally against the rejection to claim 20. Figure 3 of Thakoor does not illustrate an integrated circuit chip, but simply illustrates a circuit that can perform autonulling utilizing a WO3 think film memistor. Figure 3 also provides for no teaching of nanotechnology.

As indicated previously, Thakoor is not a nanotechnology-based device and does not employ nanoconductors such as nanotubes, nanowires, DNA, etc. Again, the H+ ions of Thakoor are not nanoconductors as such nanoconductors are known in the art (i.e., see above arguments/explanations by Applicant regarding the H+ ions of Thakoor and what is meant by the term nanotechnology).

Based on the foregoing, the Applicant submits that the rejection to claim 20 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 20 under 35 U.S.C. 102.

III. Claim Rejections – 35 U.S.C. § 103

The obligation of the examiner to go forward and produce reasoning and evidence in support of obviousness is clearly defined at M.P.E.P. §2142:

> The examiner bears the initial burden of factually supporting any *prima facie* conclusion of obviousness. If the examiner does not produce a *prima facie* case, the applicant is under no obligation to submit evidence of nonobviousness.

M.P.E.P. §2143 sets out the three basic criteria that a patent examiner must satisfy to establish a *prima facie* case of obviousness:

1. some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings;
2. a reasonable expectation of success; and
3. the teaching or suggestion of all the claim limitations by the prior art reference (or references when combined).

It follows that in the absence of such a *prima facie* showing of obviousness by the Examiner (assuming there are no objections or other grounds for rejection), an applicant is entitled to grant of a patent. *In re Oetiker*, 977 F.2d 1443, 1445, 24 USPQ2d 1443 (Fed. Cir. 1992). Thus, in order to support an obviousness rejection, the Examiner is obliged to produce evidence compelling a conclusion that each of the three aforementioned basic criteria has been met.

Thakoor in view of Deepak Srivastava, et al.

Claims 8 and 12 were rejected by the Examiner under 35 U.S.C. 103(a) as being unpatentable over Thakoor as applied to claims 1-7, 9-11 and 13-20 above, and further in view of "Computational Nanotechnology with Carbon Nanotubes and Fullerenes," by Deepak Srivastava et al, hereinafter referred to as Srivastava.

The Examiner argued that the Thakoor teaches a physical neural network configured utilizing nanotechnology wherein said physical neural network comprises a plurality of nanoconductors. The Office Action admitted that Thakoor fails to disclose that said plurality of nanoconductors includes nanoconductors comprising nanotubes.

The Examiner asserted that Srivastava teaches computational nanotechnology with carbon nanotubes and fullerenes and that it would have been obvious at the time the invention was made to a person having ordinary skill in the art to combine the physical neural network utilizing nanotechnology of Thakoor with the carbon nanotubes of Srivastava. The Examiner argued that the motivation for doing so would be to perform complex computing and switching applications in a single pass and also, the signals propagated, branched, and switched on such a network need not be restricted to the "electronic" regime (the Office Action cited page 52, left column, lines 3-11 of Srivastava in support of this argument).

The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claims 1-7, 9-11 and 13-20 under 35 U.S.C. 102 apply equally against the rejection to claims 8 and 12 under 35 U.S.C. 103. Thus, as indicated earlier, the Thakoor reference does not anticipate (inherently or otherwise) all of the claim limitations of the claims from which claims 8 and 12 depend. Thakoor therefore cannot properly be combined with Srivastava as a basis for a rejection to claims 8 and 12 under 35 U.S.C. 103.

The Applicant submits that the rejection to claims 8 and 12 under 35 U.S.C. 103 fails under all three prongs of the prima facie obviousness test described above. First, there is no suggestion or motivation either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the references or to combine the reference teaching as argued by the Examiner. The use of the electrolytic process and the hygroscopic chromium trioxide of Thakoor teaches away from any ability to combine the nanotubes of Srivastava with the solid chromium trioxide of Thakoor. This is so for two reasons. Applicant provides for a teaching of nanoconductors (e.g., nanotubes, nanowires, DNA, etc) that are disposed and free to move about in a dielectric medium. Because the memistor device is a solid-state device and the chromium trioxide of Thakoor is a solid, there is no hint, suggestion or teaching as to how the nanotubes

of Srivastava would freely move about in the chromium trioxide of Thakoor, and hence no motivation for combining the references as argued by the Examiner.

Second, as indicated previously, the chromium trioxide of Thakoor is hygroscopic and attracts water in order function as a hydrogen ion source. When water is combined with chromium trioxide, this makes for a strong acid and thus one skilled in the art would not be motivated be either Thakoor or Srivastava to use the nanotubes of Srivastava with the Thakoor device because the nanotubes of Srivastava would be corroded by the resulting acid. Third, the presence of water would also damage the nanotubes of Srivastava. There is simply not a motivation for combining the references as argued by the Examiner because doing so would simply result in damage to the nanotubes of Srivastava.

Regarding the second prong of the aforementioned prima facie obviousness test, a review of Srivastava and Thakoor reveals that there is <u>not</u> a reasonable expectation of success for combining the references as argued by the Examiner. First, combining the carbon nanotubes of Srivastava with Thakoor would mean somehow injecting or combining (which is not event hinted at in either reference how this would be accomplished) such nanotubes into or with the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor. The Applicant notes that chromium trioxide is a solid. How would such nanotubes be successfully combined with such a solid? Where is the suggestion in either Srivastava or Thakoor that such nanotubes could be combined with such a solid? The Applicant has looked for such a suggestion in the prior art references but cannot find it.

Combining nanotubes to freely move about in such a solid would be very difficult based on a reading of both the Srivastava and Thakoor references. Chromium trioxide is a dark-red, odorless flakes or powder. Thus, it is a solid. More importantly, chromium trioxide is an acid and is often referred to as chromic acid. Ethanol, for example, will ignite on contact with it. What happens when the nanotubes of Srivastava are combined with the chromic acid of Thakoor? The acid

dissolves and breaks down the nanotubes of Srivastava and renders them useless. One skilled in the art would realize this.

Additionally, Srivastava does not provide for any teaching of neural networks nor any hint or suggestion of how the nanotubes or fullerenes described in the Srivastava could be adapted for use with a physical neural network as taught by Applicant's claims 8 and 12. Page 52, left column, lines 3-11 of Srivastava provides for no hint, suggestion, or teaching of a physical neural network as taught by Applicant's claims 8 and 12. Instead, page 52 left column, lines 3-11 merely refers to a "biological neural network" but does not indicate how a carbon nanotube could be adapted for use in the physical neural network taught by Applicant's claims 8 and 12. Additionally, as indicated above, Thakoor does not describe a physical neural network as taught by Applicant's claims 8 and 12. Thus, there is no motivation for combining Srivastava and Thakoor as argued by the Office Action to derive all of the claim limitations of Applicant's claims 8 and 12. Given the presence of the chromic acid in Thakoor, it would be highly unlikely that one skilled in the art would be motivated to combine the nanotubes of Srivastava with the chromic acid in Thakoor because the chromic acid would likely severely damage the nanotubes of Srivastava and render them useless.

Additionally, both Thakoor and Srivastava fail to provide any hint, teaching or suggestion of the use of a dielectric medium as taught by Applicant's invention. As indicated previously, Thakoor provides for electrolytes and the use of chromic acid (i.e., chromium trioxide). Srivastava provides no hint of nanotubes disposed in a dielectric medium, or of the use of nanotubes in association with a dielectric and also a dielectric medium in which nanotubes are free to move about. The fact that nanotubes conduct electricity and that a dielectric is not a conductor of electricity would lead one skilled in the art to overlook any use of dielectrics with the nanotubes of Srivastava.

Regarding the third prong of the aforementioned prima facie obviousness test the Applicant submits that the rejection to claims 8 and 12 under 35 U.S.C. 103 also fails because there is no teaching or suggestion of all the claim limitations by the Srivastava and Thakoor references when combined as argued by the Examiner. In the interest of brevity the Applicant will not repeat all of the differences, but simply point out again that all of the arguments presented earlier against the rejection to the claims under 35 U.S.C. 102 apply equally against the rejection to claims 8 and 12 under 35 U.S.C. 103.

The Applicant therefore submits that the rejection to claims 8 and 12 fails under all three prongs of the aforementioned prima facie obviousness test. Based on the foregoing, the Applicant submits that the rejection to claims 8 and 12 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claims 8 and 12 under 35 U.S.C. 102.

IV. Examiner's Response to Arguments

1. Rejection of Claims 1-7, 9-11, and 13-20 under 35 U.S.C. 102

The Examiner indicated in the Office Action that the Applicant's arguments filed August 14, 2006 have been considered but that the Examiner finds them unpersuasive.

Argument 1

Regarding Argument 1 (identified by the Examiner in the Office Action), the Examiner admitted that the Applicant is correct concerning the case citations regarding anticipation. The Examiner asserted, however, that patent law is more comprehensive than Applicant recited. The Examiner indicated that she refuses to believe that Applicant is asserting that he has enumerated an exclusive list of laws that apply with respect to § 102 rejections. The Examiner again stated that "patent law is more comprehensive than that". The Examiner then proceeded to provide

examples of laws and rules that come into play in such circumstances. The Examiner cited MPEP 2112 where anticipation may be shown by "inherency". The Examiner stated that in contrast, the Applicant seems to argued that all elements in a rejection must be express in the prior art.

The Examiner argued that this is not the case. The Examiner stated that inherency is a ground for anticipation as well. The Examiner asserted that by the omission of this law in Applicant's argument, the Applicant has shown that his selections of law are overly narrow and misleading as to what is required for anticipation. The Examiner also referred to MPEP 1212 as authority for "inherency" and cited case law in In re Napier and In re Grasselli.

In addition to inherency, the Examiner indicated that Examiners are required to read the claims in their "broadest interpretation" under MPEP 2111. The Examiner argued that this is another principle used in conjunction with 102 rejections that weighs against the Applicant's implication that all claim elements must be express in the prior art. The Examiner then stated that "not all engineers use the same vocabularies for things, so one must interpret the disclosures to see if the prior art is within the 'broadest reasonable interpretation' of the claimed invention. (The Applicant reminds the Examiner that, of course, the claims must be interpreted in light of the specification).

The Examiner then stated that consequently, Applicant's recital of law are helpful, but exclusive of all other law that can and must be applied during examination. The Examiner further stated that she has applied her rejections while cognizant of all this law and asserted that the Applicant has not made a specific and cogent argument regarding the Examiner's application of law here. The Examiner then stated that Applicant's argument suggesting that claim limitations must be express in the prior art is unpersuasive and the rejections stand.

The Applicant respectfully disagrees with this analysis. First, the Applicant provided the prima facie anticipation test because the Examiner did not establish

inherency as a basis for the anticipation rejection. That is, because the Examiner did not establish inherency based under the requirements of what constitutes inherency-based anticipation, the prima facie anticipation still applies and needs to be considered by the Examiner in all cases. The Examiner should not simply ignore prima facie anticipation and argue only "inherency". The theory of inherency as a basis for an anticipation rejection should only be used under limited circumstances. The Examiner should not simply ignore the fact that a prima facie case of anticipation was not established. The Examiner should keep in mind that although inherency can be a factor for determining anticipation, so should the prima facie anticipation test presented by the Applicant.

The principle of inherency-based anticipation is more comprehensive than the Examiner recited. Simply stating that something is inherent in the prior art as a basis for arguing anticipation does not make it so. There are a number of factors that must be considered when attempting to establish inherency as a basis for anticipation. Inherency should only be applied under very limited circumstances. That is, inherency permits in very limited circumstances, an invention to be anticipated by prior art that is lacking minor, well-known features in the claimed invention. If the "missing subject matter" is "inherent" or necessarily disclosed in the prior art reference, then anticipation can exist. As stated by the Federal Circuit (see In re Sun USPQ2d 1451, 1453 (Fed. Cir. 1983)

> ...To serve as an anticipation when the reference is silent about the asserted inherent characteristic, such gap in the reference may be filled with recourse to intrinsic evidence. Such evidence must make clear that the missing descriptive matter is necessarily present in the thing described in the reference and that it would be so recognized by persons of ordinary skill.

In this regard, the CCPA has added that "'[i]nherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient". See In re Oelrich, 666 F.2d 578, 581, 212 USPQ 323, 326 (C.C.P.A. 1981) (quoting Hansgrig v. Kemmer,

102 F.2d 212, 214, 40 USPQ 665, 667 (C.C.P.A. 1930). That is, the missing element or function must necessarily result from the prior art reference.

Additionally, when an Examiner's rejection relies on inherency, it is incumbent upon the Examiner to point to the page and line of the prior art that justifies the rejection based on an inherency theory. The Examiner must not leave the Applicant to guess at the basis of the inherency rejection.

The fact that a certain result or characteristic <u>may</u> occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. *In re Rijckaert*, 9 F.3d 1531, 1534, 28 USPQ2d 1955, 1957 (Fed. Cir. 1993) (reversed rejection because inherency was based on what would result due to optimization of conditions, not what was necessarily present in the prior art); *In re Oelrich*, 666 F.2d 578, 581-82, 212 USPQ 323, 326 (CCPA 1981). "To establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.' " *In re Robertson*, 169 F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999) (citations omitted).

"In relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic <u>necessarily</u> flows from the teachings of the applied prior art." *Ex parte Levy,* 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Inter. 1990) (emphasis in original).

Argument 2

Regarding Argument 2, the Examiner provided a statement that "Applicant is reminded that although the claims are interpreted in light of the specification,

limitations from the specification are not read into the claims." The Examiner cited In re Van Geuns, F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993).

The Examiner asserted that in this argument, the Applicant admitted Thakoor teaches "synapse" and a "memistor device". The Examiner argued that in the broadest reasonable interpretation of this art, a memistor device is interpreted as a physical neural network and pre-synaptic and post-synaptic components are inherent in synapses.

This is not true. In the broadest interpretation of the memistor of Thakoor, the memistor is only a memory unit and not a physical neural network or a synapse. Thakoor only indicates that the electrochemical analog memory effects of the memistor device "...in solid state devices are potentially useful in electronic neural networks for adaptive learning and optimization applications" (see page 3135, second column, lines 1-8. In other words, the memistor is useful for use in a physical neural network but in and of itself is <u>not</u> a physical neural network or a synapse. The memistor is merely one of many devices/components that could be adapted for use with a neural network. A resistor is a device that finds usefulness and that can be adapted for use in a neural network. This does not mean that the resistor is a neural network or a synapse. A transistor is a device that is useful in electronic neural networks but also is not a neural network or a synapse. Such devices are in and of themselves not neural networks. By attempting to equate the memistor with a physical neural network, the Examiner is making an incorrect comparison to a device that is fundamentally different from a physical neural network. Also, making this comparison is a bit like saying that a brick house is equal to a brick. A more appropriate comparison for a memistor would be devices such as transistors or resistors that complement the use of a neuron or other physical neural network components.

Thakoor at page 3132, left column, lines 34-41 defines a memistor as a reprogrammable resistor with memory and as an analog memory device. Thus, in

its broadest sense, the memistor of Thakoor does not teach a synapse or neural network but merely a memory unit that has programmable and memory capabilities. In its broadest sense, the memistor, which is the focus of the Thakoor reference, is simply a memory component and therefore in the broadest and reasonable interpretation of the art can only be interpreted as a memory device. Simply because the memistor of Thakoor can be adapted for use with a neural network does not mean that the memistor, which lies at the heart of the Thakoor reference, can be interpreted as constituting a neural network or a synapse.

It is also important to understand that the memistor of Thakoor is a three-terminal device and Applicant's invention is a two-terminal device. See, for example, FIG. 1 of Thakoor, which clearly shows a gate and two electrodes, thereby constituting a three-terminal configuration. The difference between a three-terminal device and a two-terminal device is significant in building large adaptive systems. In order to assist the Examiner in appreciating this difference, we provide the following discussion, which illustrates how the two-terminal device of Applicant's invention is adaptive, whereas the three-terminal device of Thakoor is not. Imagine two electrical devices – device 1 and device 2. Device 1 is composed of three-terminals, which we will call terminals A, B, C. The conductance between terminal A and C is a function of the voltage of terminal B. In other words, by applying a certain voltage to terminal B, we may increase the conductance between terminals A and C. By applying an opposite voltage, we may weaken the conductance between terminals A and C. Now, picture the second device, device 2, which only has two terminals, which we will refer to as A and C. The conductance between terminals A and C of device 2 is a function of the accumulation of voltage over time between terminals A and C. Now, to make clear how these two devices are used, we can say the following: for device 1, the conductance between terminals A and C is a function of what we <u>do</u> to terminal B; for device 2, the conductance between terminals A and C is a function of how we <u>use</u> terminals A and C. Device 2 implies

adaptability whereas device 1 implies programmability. For example, the programmable nature of the Thakoor memistor is clearly illustrated by FIG. 2 of Thakoor, which plots the resistance as a function of the programming voltage.

To further illustrate the profound difference between programmability and adaptability, let us consider how one might make the Thakoor device adaptive according to Hebbian plasticity (i.e., Hebbian plasticity is not taught by Thakoor). Signals are represented as voltages. Hebbian plasticity is a rule for modifying the conductance of a synapse based on the accumulation of correlations between the pre- and post-synaptic electrodes. In order to modify the conductance of the Thakoor device, it would be necessary to modulate the voltage on the gate electrode of the Thakoor resistor. In other words, the gate programming voltage must be the result of a program that takes as its input the pre- and post-synaptic electrode voltages and provides as its output, the correct programming voltage. Of course, this program (i.e., circuit) is not inherent within the device of Thakoor but must be added by a designer to control (i.e., "program") the device. It is apparent how this device can be seen as only a memory element and not as an adaptive synapse because the adaptive program which is required to implement Hebbian plasticity is not present anywhere in the Thakoor memistor device.

Now consider the Applicant's device. The force felt by nanoparticles in the dielectric medium is a function of the voltage across the pre- and post-synaptic electrodes. The greater the force felt by the nanoparticles, the more nanoparticles/nanoconductors will be attracted to the connection gap. The more particles that are attracted to the connection gap, the stronger the connection becomes. One can clearly see how the conductance of the connection is a function of the voltages across the electrodes, which is the basis of plasticity and is what makes this synapse adaptive rather than programmable.

The Examiner further argued that as far as Applicant's claim for "nanoconductors" is concerned, the prior art anticipates this feature with H+ions,

which the Examiner argued are clearly measurable and verifiable to be on the nanometer scale. The Examiner asserted that the Applicant has not brought evidence to provide that H+ ions are not on the nanometer scale as the Examiner asserts.

The Examiner argued that the "nanoconductors" in Thakoor are "H+ions" (or "H+ions" as the prior art calls them). The Examiner argued that they are suspended in a "thin film of hygroscopic chromium trioxide" as the prior art calls them. The Examiner asserted that this is the "dielectric medium" of Applicant's invention.

The Applicant respectfully disagrees with these assertions. First, the Applicant is not alleging that H+ ions are not on the nanometer scale. The Applicant is asserting, however, that H+ ions and "ions" in general do not constitute nanoconductors/nanoparticles as taught by Applicant's invention. In order to understand why such "ions" are not nanoconductors/nanoparticles as taught by Applicant's invention, the Applicant believes that it would be helpful to the Examiner to understand what actually constitutes "nanotechnology". A general discussion of "nanotechnology" is provided in Applicant's "background" section as follows:

"The term "Nanotechnology" generally refers to nanometer-scale manufacturing processes, materials and devices, as associated with, for example, nanometer-scale lithography and nanometer-scale information storage. Nanometer-scale components find utility in a wide variety of fields, particularly in the fabrication of microelectrical and microelectromechanical systems (commonly referred to as "MEMS"). Microelectrical nano-sized components include transistors, resistors, capacitors and other nano-integrated circuit components. MEMS devices include, for example, micro-sensors, micro-actuators, micro-instruments, micro-optics, and the like.

In general, nanotechnology presents a solution to the problems faced in the rapid pace of computer chip design in recent years. According to Moore's law, the number of switches that can be produced on a computer chip has doubled every 18 months. Chips now can hold millions of transistors. However, it is becoming increasingly difficult to increase the number of elements on a chip using present technologies. At the present rate, in the next few years the theoretical limit of silicon based chips will be reached. Because the number of elements, which can be manufactured on a chip, determines the data storage and processing capabilities of microchips, new technologies are required which will allow for the development of higher performance chips.

Present chip technology is also limited in cases where wires must be crossed on a chip. For the most part, the design of a computer chip is limited to two dimensions. Each time a circuit is forced to cross another circuit, another layer must be added to the chip. This increases the cost and decreases the speed of the resulting chip. A number of alternatives to standard silicon based complementary metal oxide semiconductor ("CMOS") devices have been proposed. The common goal is to produce logic devices on a nanometer scale. Such dimensions are more commonly associated with molecules than integrated circuits.

Integrated circuits and electrical components thereof, which can be produced at a molecular and nanometer scale, include devices such as carbon nanotubes and nanowires, which essentially are nanoscale conductors ("nanoconductors"). Nanoconductors are tiny conductive tubes (i.e., hollow) or wires (i.e., solid) with a very small size scale (e.g., 0.7 to 300 nanometers in diameter and up to 1mm in length). Their structure and fabrication have been widely reported and are well known in the art. Carbon nanotubes, for example, exhibit a unique atomic arrangement, and possess useful physical properties such as one-dimensional electrical behavior, quantum conductance, and ballistic electron transport.

Carbon nanotubes are among the smallest dimensioned nanotube materials with a generally high aspect ratio and small diameter. High-quality single-walled carbon nanotubes can be grown as randomly oriented, needle-like or spaghetti-like tangled tubules. They can be grown by a number of fabrication methods, including chemical vapor deposition (CVD), laser ablation or electric arc growth. Carbon nanotubes can be grown on a substrate by catalytic decomposition of hydrocarbon containing precursors such as ethylene, methane, or benzene. Nucleation layers, such as thin coatings of Ni, Co, or Fe are often intentionally added onto the substrate surface in order to nucleate a multiplicity of isolated nanotubes. Carbon nanotubes can also be nucleated and grown on a substrate without a metal nucleating layer by using a precursor including one or more of these metal atoms. Semiconductor nanowires can be grown on substrates by similar processes."

The aforementioned language generally describes what is meant by "nanotechnology". Of course, it is understood by those in nanotechnology arts that variations to the aforementioned description and examples re: nanotechnology are likely to arise, but this description can be utilized as a general guideline for the context of "nanotechnology" in which Applicant's invention is provided.

With this in mind, Applicant has provided various examples of <u>nanoconductors</u> in Applicant's specification. For example, the Applicant has referred to <u>nanotubes</u>, <u>nanowires</u>, <u>nanoparticle</u> and even <u>DNA</u>. For example, Applicant's specification at paragraph [0087] indicates that "...Examples of nanoconductors include devices such as, for example, nanowires, nanotubes, and nanoparticles". Applicant's paragraph [0087] also indicates that "The network of nanoconnections

depicted in FIG. 3 can be implemented as a network of molecules, including, for example, nanoconductors." Applicant's specification at paragraph [0088] also indicates the following:

> "Nanoconnections 304, which are analogous to biological synapses, can be composed of electrical conducting material (i.e., nanoconductors). Nanoconductors can be provided in a variety of shapes and sizes without departing from the teachings herein. A nanoconductor can also be implemented as, for example, a molecule or groups of molecules."

Thus, Applicant's use of nanotechnology-based devices and components relates to multi-atom structures that are built (man-made or natural) or synthesized. DNA, for example, is a naturally constructed multi-atom structure. Free floating ions are not such structures. Atoms and atomic ions do not represent nanoparticles/nanoconductors because "nanotechnology" seeks to use atoms as the building blocks of multi-atom structures. In this light, the H+ ion of Thakoor is not a nanoconductor as taught by Applicant's invention, but rather simply just that -- an ion. Thus, it is not proper to identify the ions of Thakoor as anticipating the nanoconductors of Applicant's invention because one skilled in the art would not recognize an ion as constituting such a nanoconductor (i.e., built or synthesized multi-atom structures such as DNA, nanotubes, nanowires, etc). The ions of Thakoor do not inherently anticipate the nanoconductors taught by Applicant's invention because the Examiner has not provided a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic of nanoconductors (as taught by Applicant's invention) necessarily flows from the teachings of the applied prior art, i.e., Thakoor and the H+ ions.

Regarding the Examiner's assertion that "thin film of hygroscopic chromium trioxide" is used as a dielectric medium, the Applicant believes that it would be helpful to review what constitutes a "dielectric". A dielectric is a material that tends to concentrate an applied electric field within itself. As the dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of

the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material.

The chromium trioxide (Cr_2O_3) of Thakoor is hygroscopic as Thakoor clearly states. A "hygroscopic" is something that attracts water. Cr_2O_3 is also a solid. A dielectric does not "attract" water. In fact, if chromium trioxide were mixed with water, it would form a strong acid that would corrode the nanoconductors, not to mention the chip itself. Chromium trioxide (Cr_2O_3) does not tend to concentrate an applied electric field within itself and does not interact with the applied electric field so that charges are redistributed within atoms or molecules of the dielectric. Additionally, chromium trioxide is an electrically conductive oxide. Something that is electrically conductive, by definition, is not used as a dielectric.

Applicant's claims are directed toward nanoconductors that are free to move about in the dielectric medium. Since Applicant's invention is dealing with nanoconductors, i.e., multi-atom structures, it is not at all clear how such multi-atom structures would be free to move about within a solid such as hygroscopic chromium trioxide (Cr_2O_3). This is essentially what the Examiner is arguing and does not seem possible, since the definition of a solid is a substance whereby the constituted parts of the solid are not free to move. This is a significant difference between Applicant's invention and Thakoor.

Additionally, it is important to note that use of H+ions and the thin film of hygroscopic chromium trioxide in order to achieve the memistor of Thakoor is electrolytic in nature. Thakoor clearly states that the thin film of hygroscopic chromium trioxide (Cr_2O_3) serves as a hydrogen ion source (see Page 3132, paragraph under heading "Experimental Details" of Thakoor). The Thakoor device is thus based on an electrolytic configuration, which is the use of an electrolyte and not a dielectric. Thakoor, for example, at page 3133, second column, third paragraph, specifically refers to the use of an electrolyte. The memistor of Thakoor is based on the use of the electrochemical process of electrolysis, which is the

production of chemical changes by the passage of current through an electrolyte (not a dielectric). It is also significant to note that the Applicant's invention does not at all rely upon chemical properties but is entirely electro-mechanical. That is, Thakoor is an electrochemical device and based on an electrochemical process.

An example of such an electrochemical process is described in the "Introduction" section of Thakoor, Page 3132, Column 1, lines 34 to Column 2, line 2, where Thakoor states that "...in this paper, we report on the operational characteristics and application potential of a solid-state 'memistor," an analog memory device based on the electrochemical ion transport to/from tungsten oxide in a thin-films structure. The three-terminal devices utilizes a reversible transfer of metal (hydrogen) ions in tungsten oxide..." The use of electrolytes is taught, for example on page 3133, column 1, lines 24-26 of Thakoor where Thakoor refers to "WO_3/electrolyte display". The memistor of Thakoor thus is based on the production of chemical changes by the passage of current through an electrolyte.

An electrolyte is a substance containing free ions which behaves as an electrically conductive medium. Electrolytes are generally composed of ions in a solution of some sort. The use of free ions for a substance that behaves as electrically conductive medium, differs from that of a dielectric, which tends to concentrate an applied electric field (e-field) within itself. This is a fundamental and key difference between Thakoor and Applicant's invention. Unlike an electrolyte, such as that employed by Thakoor, as a dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. This is not true of electrolytic materials such as that used to create the memistor of Thakoor. This also not true of the hygroscopic chromium trioxide (Cr_2O_3) material of Thakoor.

Thus, to summarize, Thakoor's device is based on the use of electrolytes and in particular, the use of chromium trioxide (Cr_2O_3) as a hydrogen ion source,

whereas Applicant's device is based on the use of a dielectric medium in which nanoconductors (e.g., nanotubes, nanowires, DNA, etc.) are disposed and free to move about. Additionally, the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor is not used as a dielectric by Thakoor, and instead also tends to attract water, which could actually damage the nanoparticles and/or chip surface because when chromium trioxide is mixed with water it forms a strong acid. Note that by adding more water to chromium trioxide, more hydrogen ions will be produced, which will make for a very strong acid and thus corrode Applicant's nanoconductors (e.g., nanotubes, nanowires, DNA, etc).

Based on the foregoing, and the requirements of establishing inherency as a basis for an anticipation rejection, the use of hygroscopic chromium trioxide (Cr_2O_3) as a hydrogen source in Thakoor can not inherently anticipate the use of a dielectric medium of Applicant's invention, because in relying upon the theory of inherency, the Examiner has not provided a basis in fact and/or technical reasoning to reasonably supporting the determination that the allegedly inherent characteristic of the use of a dielectric medium and nanoconductors (e.g., nanowires, nanotubes, DNA, etc) free to move about in the dielectric medium <u>necessarily</u> flows from the teachings of the Thakoor reference.

Regarding Applicant's claim for "Hebbian learning" the Examiner argued that Thakoor on page 3133, left column, lines 1-14, "teaches the growing or lessening the conductivity of the resistance put a field to adjust the memory". The Examiner argued that such teaching, to one of ordinary skill in the art, can clearly be a learning mechanism. The Applicant asks, how does feature of Thakoor constitute a "learning mechanism"? Where does the learning take place at Thakoor on page 3133, left column, lines 1-14? How is "learning accomplished by "the growing or lessening the conductivity of the resistance put a field to adjust the memory" of Thakoor. Simply adjusting memory is not "learning". Learning is much more sophisticated and complicated process, which is not achieved simply "adjusting

memory". Additionally, and even more importantly, how does such a feature of Thakoor inherently anticipate Hebbian learning?

To one of ordinary skill in the art, Thakoor on page 3133, left column, lines 1-14, provides no hint, teaching or disclosure of "Hebbian Learning". In fact, Thakoor on page 3133, left column, lines 1-14 also does not clearly provide for a teaching of a learning mechanism. Applicant's Hebbian learning mechanism must operate in a very specific manner in order to provide for Hebbian learning. In order to understand what Hebbian learning is, the Applicant believes it would be helpful to provide a brief overview of Hebbian learning.

Hebbian learning is based on Hebbian theory, which describes a basic mechanism for synaptic plasticity wherein an increase in synaptic efficacy arises from the presynaptic cell's *repeated* and *persistent* stimulation of the postsynaptic cell. Introduced by Donald Hebb in 1949, it is also called Hebb's rule and is referred to as Hebbian learning as well. Also known as cell assembly theory, the theory is often summarized as *cells that fire together, wire together*, although this is an oversimplification of the nervous system not to be taken literally.

From the point of view of artificial neurons and artificial neural networks, Hebb's principle can be described as a method of determining how to alter the weights between model neurons as a function of their correlations of their activity in time. The weight between two neurons will increase if the two neurons activate simultaneously (they are correlated); it is reduced if they activate separately. Nodes which tend to be either both positive or both negative at the same time will have strong positive weights while those which tend to be opposite will have strong negative weights. It is sometimes stated more simply as "neurons that fire together, wire together."

This original principle is perhaps the simplest form of weight selection. While this means it can be relatively easily coded into a computer program and used to update the weights for a network, it also prohibits the number of applications of

Hebbian learning, at least with respect to software simulations of neural networks. This is because large neural networks contain massive numbers of synapses and the modification of the synapse in the traditional computing paradigm requires accessing memory. This memory access requires extraordinarily more energy than a physical neural network where synaptic states do not have to be "accessed". Today, the term *Hebbian learning* generally refers to some form of mathematical abstraction of the original principle proposed by Hebb. In this sense, Hebbian learning involves weights between learning nodes being adjusted so that each weight better represents the relationship between the nodes. As such, many learning methods can be considered to be somewhat Hebbian in nature.

The following is a formulaic description of Hebbian learning: (note that many other descriptions are possible)

$$w_{ij} = x_i x_j$$

where w_{ij} is the weight of the connection from neuron j to neuron i and x_i the input for neuron i. Note that this is pattern learning (weights updated after every training example). In a Hopfield network, connections w_{ij} are set to zero if $i = j$ (no reflexive connections allowed). With binary neurons (activations either 0 or 1), connections would be set to 1 if the connected neurons have the same activation for a pattern.

Another formulaic description is:

$$w_{ij} = \frac{1}{n} \sum_{k=1}^{p} x_i^k x_j^k ,$$

where w_{ij} is the weight of the connection from neuron j to neuron i, n is the dimension of the input vector, p the number of training patterns, and x_i^k the kth input for neuron i. The Applicant invites the Examiner to view the following web site, which contains a good general overview of Hebbian learning:

http://en.wikipedia.org/wiki/Hebbian_learning

Based on a review of Thakoor and a basic understanding of Hebbian learning it is very clear that Thakoor does not provide for any teaching, suggestion or disclosure of Hebbian learning. Additionally, it is very clear that Thakoor does not inherently anticipate Hebbian learning, and thus the Hebbian learning mechanism provided by Applicant's invention. The Examiner has not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory".

Regarding the Examiner's assertion that the Applicant admitted Thakoor teaches "synapse" and a "memistor device", the Applicant respectfully disagrees with this assessment. The Applicant does not admit that the memistor device is a synapse or physical neural network. The memistor device of Thakoor (see FIG. 3 of Thakoor, for example) functions in the context of an autonulling circuit, and is <u>not</u> in and of itself a synapse or a neuron. A review of FIG. 3 of Thakoor, for example, shows that the WO_3 based memistor is connected to an offset amplifier and a neuron but in and of itself is not a synapse or a neuron. In FIG. 3 of Thakoor, the neuron to be autonulled is actually separate from the memistor. In no way does Thakoor teach, disclose or suggest actual synapses. Again, FIG. 3 is simply performing an automatic offset nulling of a differential operational amplifier. The terminal labeled Vin depicted in FIG. 3 of Thakoor is where the supposed inputs from synaptic connections would occur but of course these are not shown in Thakoor. In fact, the FIG. 3 circuit is nothing more than a neuron voice of synapses, and certainly, the memistor shown in FIG. 3 is not a synapse and does not even posses pre- and post-synaptic electrodes.

The Examiner's argument that in the broadest reasonable interpretation of this art, a memistor device is interpreted as a physical neural network and pre-synaptic

and post-synaptic components are inherent in synapses is incorrect because the memistor as explained above is not a physical neural network nor a synapse. If the Examiner would please identify the pre- and post-synaptic terminals in Thakoor, it would be helpful to the Applicant because the Applicant see three terminals in Thakoor as indicated previously. Instead, the memistor of Thakoor is simply a component, such as a resistor or amplifier, that complements the neuron of Thakoor, but itself is not a physical neural network or a synapse, and is not a pre-synaptic and post-synaptic electrode. Additionally, the Examiner's arguments with respect to inherency fails because the Examiner has not explained how and why the "missing elements or functions" of the Applicant's claims must necessarily result from the Thakoor reference. That is, the memistor itself is not a physical neural network and does not include a Hebbian learning mechanism, and the use of a dielectric medium comprising a mixture of a dielectric solvent and a plurality of nanoconductors wherein such nanoconductors are free to move about in the dielectric medium. Such features would not "inherently" result from even the slightest modification of Thakoor.

Argument 3

The Examiner asserted that regarding Applicant's claim for "Hebbian learning," Thakoor on page 3133, left column, line 1-14, teaches "the growing or lessening the conductivity of the resistance put a field to adjust memory." The Examiner asserted that such teaching, to one of ordinary skill in the art, can clearing be a learning, mechanism, i.e., Hebbian learning.

As far as the Applicant's claim for Hebbian plasticity or anti-Hebbian plasticity is concerned, the Examiner argued that the Thakoor reference anticipates this feature in FIG. 2 of Thakoor. The Examiner argued that FIG. 2 illustrates the variation in resistance with time for several different control voltages. The Examiner argued that plasticity by definition is the ability to develop or adapt in

response to the environment. The Examiner further asserted that "another word, the ability to learn or unlearn" and that "as responded above regarding Hebbian learning, the growing or lessening the conductivity of the resistance put a field to adjust memory". The Examiner therefore asserted that the learning or unlearning is being performed by Thakoor.

The Applicant respectfully disagrees with this assessment and notes that the arguments provided above against the Examiner's assertions with respect to Argument 2 and the issue of the Hebbian learning mechanism apply equally against the Examiner's assertions with respect to Argument 3. In the interest of brevity, the Applicant will not repeat these arguments, except to point out again that the Examiner has not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory". One of ordinary skill in the art would not see this as teaching or inherently anticipating <u>Hebbian</u> learning. Hebbian learning is a very specific type of neural network learning mechanism, and there is not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor. Simply "growing or lessening the conductivity of the resistance put a field to adjust the memory" does not inherently anticipate the Hebbian learning mechanism of Applicant's invention.

Regarding "Hebbian plasticity" or "anti-Hebbian plasticity," a review of FIG. 2 of Thakoor does not indicate any suggestion, disclosure and/or teaching of Hebbian plasticity or anti-Hebbian plasticity. The Examiner argued that "plasticity" is the ability to develop or adapt in response to the environment, or the ability to learn or unlearn. This is an oversimplification of a concept that is inherently more complex

and sophisticated than the definition provided by the Examiner. The memistor is a memory device but not a learning mechanism. The "memistor" characteristics disclosed in FIG. 2 relate only to "turn on" and "turn off" characteristics of the memistor. The memistor exhibits electrochemical analog memory effects but does not learn anything. The memistor merely achieves device programmability over a wide range of resistances.

FIG. 2 of Thakoor is simply a plot of resistance versus time for several control voltages for a turning the device "on" and "off". Thakoor. FIG. 2 does not suggest, disclose or teach any sort of "learning" or "unlearning". The Examiner has merely made a statement that FIG. 2 illustrates an ability to learn or adapting to the environment and hence illustrates "learning". FIG. 2 merely describes "turn-on" and "turn-off" characteristics of the Thakoor device, but does not illustrate a device that has the ability to develop or adapt in response to the environment. The Examiner's arguments do not adequately explain how one skilled in the art would identify FIG. 2 as illustrating plasticity and more importantly, Hebbian plasticity or anti-Hebbian plasticity or the performance of any sort of "learning" or "unlearning". Based on the foregoing, the Applicant submits that there is simply not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian plasticity or anti-Hebbian plasticity flows from the teachings from the test device programming characteristics for variations in resistance of test device with time for several different control voltages of Thakoor's FIG. 2. Plasticity and Hebbian plasticity in particular are very specific types of neural network features, and there is clearly not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian plasticity necessarily flows from the teachings from Thakoor. Thus, FIG. 2 of Thakoor does not inherently anticipate Hebbian and/or anti-Hebbian plasticity, or learning/unlearning and not even plasticity.

Argument 4

Regarding Applicant's claim for Hebbian learning, the Examiner again cited Thakoor on page 3133, left column, lines 1-14 where Thakoor teaches the "growing or lessening the conductivity of the resistance put a field to adjust the memory" and asserted that this teaching, to one of ordinary kill in the art, can clearly be a learning mechanism, i.e., Hebbian learning.

The Examiner stated that "as responded earlier, Thakoor teaches 'synapses' and pre-synaptic and post-synaptic components are inherent in synapses".

The Applicant respectfully disagrees with this assessment and notes that the arguments provided above against the Examiner's assertions with respect to Argument 2 and the issue of the Hebbian learning mechanism apply equally against the Examiner's assertions with respect to Argument 4. In the interest of brevity, the Applicant will not repeat these arguments, except to point out again that the Examiner has not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory". This is simply not a learning mechanism and of course is not Hebbian learning. One of ordinary skill in the art would not see the Examiner's cited teaching of Thakoor or inherently anticipating <u>Hebbian</u> learning. Hebbian learning is a very specific type of neural network learning mechanism, and there is not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor. Simply "growing or lessening the conductivity of the resistance put a field to adjust the memory" does not inherently anticipate the Hebbian learning mechanism of Applicant's invention and one skilled in the art would clearly not see this as a learning mechanism, including Hebbian learning.

Argument 5

Regarding Argument 5, the Examiner asserted that as far Applicant's claim for "Hebbian plasticity" or "anti-Hebbian plasticity" is concerned, Thakoor anticipates this feature in FIG. 2. The Examiner asserted that FIG. 2 illustrates the variation in resistance with time for several different control voltages. The Examiner argued that plasticity by definition is the ability to develop or adapt in response to the environment. The Examiner also stated that "another word, the ability to learn or unlearn."

The Examiner also stated that "as responded above regarding Hebbian learning, the growing or lessening the conductivity of resistance put a field to adjust the memory" and argued that the learning or unlearning is being performed.

The Applicant respectfully disagrees with this assessment and notes that the arguments provided above against the Examiner's assertions with respect to Argument 2 and the issue of the Hebbian learning mechanism apply equally against the Examiner's assertions with respect to Argument 5. In the interest of brevity, the Applicant will not repeat these arguments, except to point out again that the Examiner has not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory". One of ordinary skill in the art would not see this as teaching or inherently anticipating <u>Hebbian</u> learning. Hebbian learning is a very specific type of neural network learning mechanism, and there is not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor. Simply "growing or lessening the conductivity of the resistance put a field

to adjust the memory" does not inherently anticipate the Hebbian learning mechanism of Applicant's invention.

Regarding "Hebbian plasticity" or "anti-Hebbian plasticity," a review of FIG. 2 of Thakoor does not indicate any suggestion, disclosure and/or teaching of Hebbian plasticity or anti-Hebbian plasticity. The Examiner argued that "plasticity" is the ability to develop or adapt in response to the environment, or the ability to learn or unlearn. This is an oversimplification of a concept that is inherently more complex and sophisticated than the definition provided by the Examiner. FIG. 2 of Thakoor is simply a plot of resistance versus time for several control voltages for a turning the device "on" and "off". Thakoor. FIG. 2 does not suggest, disclose or teach any sort of "learning" or "unlearning". The Examiner has merely made a statement that FIG. 2 illustrates an ability to learn or adapting to the environment and hence illustrates "learning".

FIG. 2 merely describes "turn-on" and "turn-off" characteristics of the Thakoor device, but does not illustrate a device that has the ability to develop or adapt in response to the environment. The Examiner's arguments do not adequately explain how one skilled in the art would identify FIG. 2 as illustrating plasticity and more importantly, Hebbian plasticity or anti-Hebbian plasticity or the performance of any sort of "learning" or "unlearning". Based on the foregoing, the Applicant submits that there is simply not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian plasticity or anti-Hebbian plasticity flows from the teachings from the test device programming characteristics for variations in resistance of test device with time for several different control voltages of Thakoor's FIG. 2. Thus, FIG. 2 of Thakoor does not anticipate Hebbian and/or anti-Hebbian plasticity, nor learning/unlearning nor even plasticity.

Argument 6

Regarding Argument 6 and Applicant's claim for anti-Hebbian learning, the Examiner argued that Thakoor on page 3133, left column, lines 1-14, teaches the "growing or lessening the conductivity of the resistance put a field to adjust the memory". The Examiner asserted that such teaching, to one of ordinary skill in the art, can clearly be a learning mechanism, i.e., anti-Hebbian learning.

The Applicant asks, how do the features of Thakoor the Examiner cited with respect to page 3133, left column, lines 1-14 constitute a "learning mechanism" and specifically anti-Hebbian learning. How and why are anti-Hebbian learning accomplished by "the growing or lessening the conductivity of the resistance put a field to adjust the memory" of Thakoor. Simply adjusting memory is not "anti-Hebbian learning". Anti-Hebbian learning is a much more sophisticated and complicated process, which is not achieved simply "adjusting memory". Additionally, and even more importantly, how does such a feature of Thakoor inherently anticipate <u>anti-Hebbian</u> learning?

To one of ordinary skill in the art, Thakoor on page 3133, left column, lines 1-14, provides no hint, teaching or disclosure of "anti-Hebbian Learning". In fact, Thakoor on page 3133, left column, lines 1-14 also does not clearly provide for a teaching of a <u>learning</u> mechanism. Applicant's <u>anti-Hebbian</u> learning mechanism must operate in a very specific manner in order to provide for <u>anti-Hebbian</u> learning. In order to understand what anti-Hebbian learning is, the Applicant believes it would be helpful for the Examiner to refer to the brief overview of Hebbian learning provided early. Hebbian learning is based on <u>Hebbian</u> theory, which describes a basic mechanism for synaptic plasticity wherein an increase in synaptic efficacy arises from the presynaptic cell's *repeated* and *persistent* stimulation of the postsynaptic cell. Hebbian theory and Hebbian learning is simply not anticipated inherently or otherwise anywhere within Thakoor. In general, Hebbian learning can thus be implemented in neural networks as a technique for modifying connection based on correlations in pre- and post-synaptic activity. Anti-

Hebbian learning is essentially the opposite of Hebbian-based learning techniques. In anti-Hebbian learning, the connections are weakened when connections and/or neurons are correlated in activity, and strengthened when pre- and post-synaptic activity is anti-correlated. Such anti-Hebbian learning is not suggested, disclosed or taught by Thakoor no page 3133, left column, lines 1-14 cited by the Examiner.

Based on a review of Thakoor and a basic understanding of Hebbian learning it is very clear that Thakoor does not provide for any teaching, suggestion or disclosure of anti-Hebbian learning. Additionally, it is very clear that Thakoor does not inherently anticipate anti-Hebbian learning, and thus the Hebbian learning mechanism provided by Applicant's invention. The Examiner has not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of anti-Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory"

The Examiner stated that as responded earlier, that Thakoor teaches "synapse" and pre-synaptic and post-synaptic components are inherent in synapses. The Applicant notes, however, that the memistor of Thakoor is not a synapse but works in association with the neuron to be autonulled (see FIG. 3 of Thakoor).

Regarding the Applicant's claim for nanoconductors is concerned, the Examiner asserted that the Applicant argued that the prior art anticipates this feature with H+ ions, arguing that these are clearly measurable and verifiable to be on the nanometer scale. The Examiner asserted that the Applicant has not brought evidence to prove that H+ ions are not on the nanometer scale as the Examiner asserts.

The Applicant respectfully disagrees with these assertions. First, the Applicant is not alleging that H+ ions are not on the nanometer scale. The Applicant is

asserting, however, that H+ ions and "ions" in general do not constitute nanoconductors/nanoparticles taught by Applicant's invention. In order to understand why such "ions" are not nanoconductors/nanoparticles as taught by Applicant's invention, the Applicant believes that it would be helpful to the Examiner to understand what actually constitutes "nanotechnology". A general discussion of "nanotechnology" is provided in Applicant's "background" section as follows:

"The term "Nanotechnology" generally refers to nanometer-scale manufacturing processes, materials and devices, as associated with, for example, nanometer-scale lithography and nanometer-scale information storage. Nanometer-scale components find utility in a wide variety of fields, particularly in the fabrication of microelectrical and microelectromechanical systems (commonly referred to as "MEMS"). Microelectrical nano-sized components include transistors, resistors, capacitors and other nano-integrated circuit components. MEMS devices include, for example, micro-sensors, micro-actuators, micro-instruments, micro-optics, and the like.

In general, nanotechnology presents a solution to the problems faced in the rapid pace of computer chip design in recent years. According to Moore's law, the number of switches that can be produced on a computer chip has doubled every 18 months. Chips now can hold millions of transistors. However, it is becoming increasingly difficult to increase the number of elements on a chip using present technologies. At the present rate, in the next few years the theoretical limit of silicon based chips will be reached. Because the number of elements, which can be manufactured on a chip, determines the data storage and processing capabilities of microchips, new technologies are required which will allow for the development of higher performance chips.

Present chip technology is also limited in cases where wires must be crossed on a chip. For the most part, the design of a computer chip is limited to two dimensions. Each time a circuit is forced to cross another circuit, another layer must be added to the chip. This increases the cost and decreases the speed of the resulting chip. A number of alternatives to standard silicon based complementary metal oxide semiconductor ("CMOS") devices have been proposed. The common goal is to produce logic devices on a nanometer scale. Such dimensions are more commonly associated with molecules than integrated circuits.

Integrated circuits and electrical components thereof, which can be produced at a molecular and nanometer scale, include devices such as carbon nanotubes and nanowires, which essentially are nanoscale conductors ("nanoconductors"). Nanoconductors are tiny conductive tubes (i.e., hollow) or wires (i.e., solid) with a very small size scale (e.g., 0.7 to 300 nanometers in diameter and up to 1mm in length). Their structure and fabrication have been widely reported and are well known in the art. Carbon nanotubes, for example, exhibit a unique atomic arrangement, and possess useful physical properties such as one-dimensional electrical behavior, quantum conductance, and ballistic electron transport.

Carbon nanotubes are among the smallest dimensioned nanotube materials with a generally high aspect ratio and small diameter. High-quality single-walled carbon nanotubes

can be grown as randomly oriented, needle-like or spaghetti-like tangled tubules. They can be grown by a number of fabrication methods, including chemical vapor deposition (CVD), laser ablation or electric arc growth. Carbon nanotubes can be grown on a substrate by catalytic decomposition of hydrocarbon containing precursors such as ethylene, methane, or benzene. Nucleation layers, such as thin coatings of Ni, Co, or Fe are often intentionally added onto the substrate surface in order to nucleate a multiplicity of isolated nanotubes. Carbon nanotubes can also be nucleated and grown on a substrate without a metal nucleating layer by using a precursor including one or more of these metal atoms. Semiconductor nanowires can be grown on substrates by similar processes."

The aforementioned language generally describes what is meant by "nanotechnology". Of course, it is understood by those in nanotechnology arts that variations to the aforementioned description and examples re: nanotechnology are likely to arise, but this description can be utilized as a general guideline for the context of "nanotechnology" in which Applicant's invention is provided.

With this in mind, Applicant has provided various examples of <u>nanoconductors</u> in Applicant's specification. For example, the Applicant has referred to <u>nanotubes</u>, <u>nanowires</u>, <u>nanoparticle</u> and even <u>DNA</u>. For example, Applicant's specification at paragraph [0087] indicates that "...Examples of nanoconductors include devices such as, for example, nanowires, nanotubes, and nanoparticles". Applicant's paragraph [0087] also indicates that "The network of nanoconnections depicted in FIG. 3 can be implemented as a network of molecules, including, for example, nanoconductors." Applicant's specification at paragraph [0088) also indicates the following:

"Nanoconnections 304, which are analogous to biological synapses, can be composed of electrical conducting material (i.e., nanoconductors). Nanoconductors can be provided in a variety of shapes and sizes without departing from the teachings herein. A nanoconductor can also be implemented as, for example, a molecule or groups of molecules."

Thus, Applicant's use of nanotechnology-based devices and components relates to multi-atom structures that are built (man-made or natural) or synthesized. DNA, for example, is a naturally constructed multi-atom structure.

Free floating ions are not such structures. Atoms and atomic ions do not represent nanoparticles/nanoconductors because "nanotechnology" seeks to use atoms as the building blocks of multi-atom structures. In this light, the H+ ion of Thakoor is not a nanoconductor as taught by Applicant's invention, but rather simply just that -- an ion. Thus, it is not proper to identify the ions of Thakoor as anticipating the nanoconductors of Applicant's invention because one skilled in the art would not recognize an ion as constituting such a nanoconductor (i.e., built or synthesized multi-atom structures such as DNA, nanotubes, nanowires, etc). The ions of Thakoor do not inherently anticipate the nanoconductors taught by Applicant's invention because the Examiner has not provided a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic of nanoconductors (as taught by Applicant's invention) necessarily flows from the teachings of the applied prior art, i.e., Thakoor and the H+ ions.

Argument 7

Regarding Argument 7, the Examiner argued that the Applicant freely admitted that H_xWO_3 is a chemical compound. The Examiner stated that nanowires or nanoparticles by definition, are components of nanotechnology to create electrical circuits out of chemical compounds that are capable of being formed into extremely small circuits. The Applicant respectfully disagrees with this assessment. H_xWO_3 is simply a chemical compound and is not a nanowire, a nanotube, DNA, or any other type of nanoconductor as taught by Applicant's invention. Simply because a thing is a chemical compound does not mean that it functions as a nanoconductor under the definition of nanotechnology.

The H_xWO_3 material of Thakoor does not inherently anticipate the nanoconductors taught by Applicant's invention because the Examiner has not provided a basis in fact and/or technical reasoning to reasonably support the

determination that the allegedly inherent characteristic of nanoconductors (as taught by Applicant's invention) necessarily flows from the teachings of Thakoor.

Argument 8

Regarding Argument 8, the Examiner reminded the Applicant that although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. The Examiner argued that in this argument, the Applicant admitted that Thakoor teaches "synapses" and a "memistor device". The Examiner argued that in the broadest reasonable interpretation of this art, a memistor device is interpreted as a physical neural network and pre-synaptic and post-synaptic components are inherent in synapses.

The Applicant respectfully disagrees with this assessment. In the broadest reasonable interpretation of Thakoor, the memistor device is neither a synapse nor a physical neural network, but simply a device that complements the neuron to be annulled (see FIG. 3 of Thakoor). Thus the memistor device itself does not teach, suggest or anticipate a physical neural network or two separate pre-synaptic and post-synaptic components.

The Examiner further argued that as far as Applicant's claim for "nanoconductors" is concerned, the prior art anticipates this feature with H+ions, which the Examiner argued are clearly measurable and verifiable to be on the nanometer scale. The Examiner asserted that the Applicant has not brought evidence to provide that H+ ions are not on the nanometer scale as the Examiner asserts.

The Examiner argued that the "nanoconductors" in Thakoor are "H+ions" (or "H+ions" as the prior art calls them). The Examiner argued that they are suspended in a "thin film of hygroscopic chromium trioxide" as the prior art calls them. The Examiner asserted that this is the "dielectric medium" of Applicant's invention.

The Applicant respectfully disagrees with these assertions. First, the Applicant is not alleging that H+ ions are not on the nanometer scale. The Applicant is asserting, however, that H+ ions and "ions" in general do not constitute nanoconductors/nanoparticles taught by Applicant's invention. In order to understand why such "ions" are not nanoconductors/nanoparticles as taught by Applicant's invention, the Applicant believes that it would be helpful to the Examiner to understand what actually constitutes "nanotechnology". A general discussion of "nanotechnology" is provided in Applicant's "background" section as follows:

"The term "Nanotechnology" generally refers to nanometer-scale manufacturing processes, materials and devices, as associated with, for example, nanometer-scale lithography and nanometer-scale information storage. Nanometer-scale components find utility in a wide variety of fields, particularly in the fabrication of microelectrical and microelectromechanical systems (commonly referred to as "MEMS"). Microelectrical nano-sized components include transistors, resistors, capacitors and other nano-integrated circuit components. MEMS devices include, for example, micro-sensors, micro-actuators, micro-instruments, micro-optics, and the like.

In general, nanotechnology presents a solution to the problems faced in the rapid pace of computer chip design in recent years. According to Moore's law, the number of switches that can be produced on a computer chip has doubled every 18 months. Chips now can hold millions of transistors. However, it is becoming increasingly difficult to increase the number of elements on a chip using present technologies. At the present rate, in the next few years the theoretical limit of silicon based chips will be reached. Because the number of elements, which can be manufactured on a chip, determines the data storage and processing capabilities of microchips, new technologies are required which will allow for the development of higher performance chips.

Present chip technology is also limited in cases where wires must be crossed on a chip. For the most part, the design of a computer chip is limited to two dimensions. Each time a circuit is forced to cross another circuit, another layer must be added to the chip. This increases the cost and decreases the speed of the resulting chip. A number of alternatives to standard silicon based complementary metal oxide semiconductor ("CMOS") devices have been proposed. The common goal is to produce logic devices on a nanometer scale. Such dimensions are more commonly associated with molecules than integrated circuits.

Integrated circuits and electrical components thereof, which can be produced at a molecular and nanometer scale, include devices such as carbon nanotubes and nanowires, which essentially are nanoscale conductors ("nanoconductors"). Nanoconductors are tiny conductive tubes (i.e., hollow) or wires (i.e., solid) with a very small size scale (e.g., 0.7 to 300 nanometers in diameter and up to 1mm in length). Their structure and fabrication have been widely reported and are well known in the art. Carbon nanotubes, for example, exhibit

a unique atomic arrangement, and possess useful physical properties such as one-dimensional electrical behavior, quantum conductance, and ballistic electron transport.

Carbon nanotubes are among the smallest dimensioned nanotube materials with a generally high aspect ratio and small diameter. High-quality single-walled carbon nanotubes can be grown as randomly oriented, needle-like or spaghetti-like tangled tubules. They can be grown by a number of fabrication methods, including chemical vapor deposition (CVD), laser ablation or electric arc growth. Carbon nanotubes can be grown on a substrate by catalytic decomposition of hydrocarbon containing precursors such as ethylene, methane, or benzene. Nucleation layers, such as thin coatings of Ni, Co, or Fe are often intentionally added onto the substrate surface in order to nucleate a multiplicity of isolated nanotubes. Carbon nanotubes can also be nucleated and grown on a substrate without a metal nucleating layer by using a precursor including one or more of these metal atoms. Semiconductor nanowires can be grown on substrates by similar processes."

The aforementioned language generally describes what is meant by "nanotechnology". Of course, it is understood by those in nanotechnology arts that variations to the aforementioned description and examples re: nanotechnology are likely to arise, but this description can be utilized as a general guideline for the context of "nanotechnology" in which Applicant's invention is provided.

With this in mind, Applicant has provided various examples of <u>nanoconductors</u> in Applicant's specification. For example, the Applicant has referred to <u>nanotubes</u>, <u>nanowires</u>, <u>nanoparticle</u> and even <u>DNA</u>. For example, Applicant's specification at paragraph [0087] indicates that "...Examples of nanoconductors include devices such as, for example, nanowires, nanotubes, and nanoparticles". Applicant's paragraph [0087] also indicates that "The network of nanoconnections depicted in FIG. 3 can be implemented as a network of molecules, including, for example, nanoconductors." Applicant's specification at paragraph [0088) also indicates the following:

"Nanoconnections 304, which are analogous to biological synapses, can be composed of electrical conducting material (i.e., nanoconductors). Nanoconductors can be provided in a variety of shapes and sizes without departing from the teachings herein. A nanoconductor can also be implemented as, for example, a molecule or groups of molecules."

Thus, Applicant's use of nanotechnology-based devices and components relates to multi-atom structures that are built (man-made or natural) or synthesized. DNA, for example, is a naturally constructed multi-atom structure. Free floating ions are not such structures. Atoms and atomic ions do not represent nanoparticles/nanoconductors because "nanotechnology" seeks to use atoms as the building blocks of multi-atom structures. In this light, the H+ ion of Thakoor is not a nanoconductor as taught by Applicant's invention, but rather simply just that -- an ion. Thus, it is not proper to identify the ions of Thakoor as anticipating the nanoconductors of Applicant's invention because one skilled in the art would not recognize an ion as constituting such a nanoconductor (i.e., built or synthesized multi-atom structures such as DNA, nanotubes, nanowires, etc). The ions of Thakoor do not inherently anticipate the nanoconductors taught by Applicant's invention because the Examiner has not provided a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic of nanoconductors (as taught by Applicant's invention) necessarily flows from the teachings of the applied prior art, i.e., Thakoor and the H+ ions.

Regarding Applicant's claim for "Hebbian learning" the Examiner argued that Thakoor on page 3133, left column, lines 1-14, "teaches the growing or lessening the conductivity of the resistance put a field to adjust the memory". The Examiner argued that such teaching, to one of ordinary skill in the art, can clearly be a learning mechanism. The Applicant asks, wow does feature of Thakoor constitute a "learning mechanism"? How is "learning accomplished by "the growing or lessening the conductivity of the resistance put a field to adjust the memory" of Thakoor. Simply adjusting memory is not "learning". Learning is much more sophisticated and complicated process, which is not achieved simply "adjusting memory". Additionally, and even more importantly, how does such a feature of Thakoor inherently anticipate Hebbian learning?

To one of ordinary skill in the art, Thakoor on page 3133, left column, lines 1-14, provides no hint, teaching or disclosure of "Hebbian Learning". In fact, Thakoor on page 3133, left column, lines 1-14 also does not clearly provide for a teaching of a <u>learning</u> mechanism. Applicant's <u>Hebbian</u> learning mechanism must operate in a very specific manner in order to provide for <u>Hebbian</u> learning. In order to understand what Hebbian learning is, the Applicant believes it would be helpful to provide a brief overview of Hebbian learning.

Hebbian learning is based on <u>Hebbian</u> theory, which describes a basic mechanism for synaptic plasticity wherein an increase in synaptic efficacy arises from the presynaptic cell's *repeated* and *persistent* stimulation of the postsynaptic cell. Introduced by Donald Hebb in 1949, it is also called Hebb's rule and is referred to as Hebbian learning as well. Also known as cell assembly theory, the theory is often summarized as *cells that fire together, wire together*, although this is an oversimplification of the nervous system not to be taken literally.

From the point of view of artificial neurons and artificial neural networks, Hebb's principle can be described as a method of determining how to alter the weights between model neurons as a function of their correlations of their activity in time. The weight between two neurons will increase if the two neurons activate simultaneously (they are correlated); it is reduced if they activate separately. Nodes which tend to be either both positive or both negative at the same time will have strong positive weights while those which tend to be opposite will have strong negative weights. It is sometimes stated more simply as "neurons that fire together, wire together."

This original principle is perhaps the simplest form of weight selection. While this means it can be relatively easily coded into a computer program and used to update the weights for a network, it also prohibits the number of applications of Hebbian learning, at least with respect to software simulations of neural networks. This is because large neural networks contain massive numbers of synapses and

the modification of the synapse in the traditional computing paradigm requires accessing memory. This memory access requires extraordinarily more energy than a physical neural network where synaptic states do not have to be "accessed". Today, the term *Hebbian learning* generally refers to some form of mathematical abstraction of the original principle proposed by Hebb. In this sense, Hebbian learning involves weights between learning nodes being adjusted so that each weight better represents the relationship between the nodes. As such, many learning methods can be considered to be somewhat Hebbian in nature.

The following is a formulaic description of Hebbian learning: (note that many other descriptions are possible)

$$w_{ij} = x_i x_j$$

where w_{ij} is the weight of the connection from neuron j to neuron i and x_i the input for neuron i. Note that this is pattern learning (weights updated after every training example). In a Hopfield network, connections w_{ij} are set to zero if $i = j$ (no reflexive connections allowed). With binary neurons (activations either 0 or 1), connections would be set to 1 if the connected neurons have the same activation for a pattern.

Another formulaic description is:

$$w_{ij} = \frac{1}{n} \sum_{k=1}^{p} x_i^k x_j^k ,$$

where w_{ij} is the weight of the connection from neuron j to neuron i, n is the dimension of the input vector, p the number of training patterns, and x_i^k the kth input for neuron i. The Applicant invites the Examiner to view the following web site, which contains a good general overview of Hebbian learning:

http://en.wikipedia.org/wiki/Hebbian_learning

Based on a review of Thakoor and a basic understanding of Hebbian learning it is very clear that Thakoor does not provide for any teaching, suggestion or

disclosure of Hebbian learning. Additionally, it is very clear that Thakoor does not inherently anticipate Hebbian learning, and thus the Hebbian learning mechanism provided by Applicant's invention. The Examiner has not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory"

Regarding "Hebbian plasticity" or "anti-Hebbian plasticity," a review of FIG. 2 of Thakoor does not indicate any suggestion, disclosure and/or teaching of Hebbian plasticity or anti-Hebbian plasticity. The Examiner argued that "plasticity" is the ability to develop or adapt in response to the environment, or the ability to learn or unlearn. This is an oversimplification of a concept that is inherently more complex and sophisticated than the definition provided by the Examiner. FIG. 2 of Thakoor is simply a plot of resistance versus time for several control voltages for a turning the device "on" and "off". Thakoor. FIG. 2 does not suggest, disclose or teach any sort of "learning" or "unlearning". The Examiner has merely made a statement that FIG. 2 illustrates an ability to learn or adapting to the environment and hence illustrates "learning". FIG. 2 merely describes "turn-on" and "turn-off" characteristics of the Thakoor device, but does not illustrate a device that has the ability to develop or adapt in response to the environment. The Examiner's arguments do not adequately explain how one skilled in the art would identify FIG. 2 as illustrating plasticity and more importantly, Hebbian plasticity or anti-Hebbian plasticity or the performance of any sort of "learning" or "unlearning". Based on the foregoing, the Applicant submits that there is simply not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian plasticity or anti-Hebbian plasticity flows from the teachings from the test device programming characteristics for variations in

resistance of test device with time for several different control voltages of Thakoor's FIG. 2. Thus, FIG. 2 of Thakoor does not anticipate Hebbian and/or anti-Hebbian plasticity, nor learning/unlearning nor even plasticity.

Argument 9

Regarding Argument 9, the Examiner asserted that the Applicant freely admitted that H_xWO_3 is a chemical compound. The Examiner stated that nanowires or nanoparticles by definition, are components of nanotechnology to create electrical circuits out of chemical compounds that are capable of being formed into extremely small circuits. The Applicant respectfully disagrees with this assessment. H_xWO_3 is simply a chemical compound and is not a nanowire, a nanotube, DNA, or any other type of nanoconductor as taught by Applicant's invention. Simply because a thing is a chemical compound does not mean that it functions as a nanoconductor under the definition of nanotechnology.

A nanowire by definition is a much more complicated and versatile device than just a chemical compound such as H_xWO_3. In order to understand what a nanowire is, the Applicant believes it would be helpful for the Examiner to review the information about nanowires freely available at the following web site:

http://en.wikipedia.org/wiki/Nanowire

The first thing to appreciate about a nanowire is that it is a wire. The H_xWO_3 of Thakoor is not a wire. A nanowire is a <u>wire</u> of dimensions of the order of a nanometer (10^{-9} meters). Alternatively, nanowires can be defined as structures that have a lateral size constrained to tens of nanometers or less and an unconstrained longitudinal size. At these scales, quantum mechanical effects are important — hence such wires are also known as "quantum wires". Many different types of nanowires exist, including metallic (e.g., Ni, Pt, Au), semiconducting (e.g., InP, Si, GaN, etc.), and insulating (e.g., SiO_2,TiO_2). Molecular nanowires are

composed of repeating molecular units either organic (e.g. DNA) or inorganic (e.g. $Mo_6S_{9-x}I_x$).

Typical nanowires exhibit aspect ratios (the ratio between length to width) of 1000 or more. As such they are often referred to as 1-Dimensional materials. Nanowires have many interesting properties that are not seen in bulk or 3-D materials. This is because electrons in nanowires are quantum confined laterally and thus occupy energy levels that are different from the traditional continuum of energy levels or bands found in bulk materials. Peculiar features of this quantum confinement exhibited by certain nanowires such as carbon nanotubes manifest themselves in discrete values of the electrical conductance. Such discrete values arise from a quantum mechanical restraint on the number of electrons that can travel through the wire at the nanometer scale. These discrete values are often referred to as the quantum of conductance and are integer values of $\frac{2e^2}{h} \approx 12.9\ k\Omega^{-1}$. They are inverse of the well-known resistance unit h/e^2, which is roughly equal to 25812.8 ohms, and referred to as the von Klitzing constant R_K (after Klaus von Klitzing, the discoverer of exact quantization). Since 1990, a fixed conventional value R_{K-90} is accepted.

Examples of nanowires include inorganic molecular nanowires ($Mo_6S_{9-x}I_x$), which have a diameter of 0.9 nm, and can be hundreds of micrometers long. Other important examples are based on semiconductors such as InP, Si, GaN, etc., dielectrics (e.g. SiO_2,TiO_2), or metals (e.g. Ni, Pt).

The H_xWO_3 material of Thakoor is therefore not a nanowire. FIG. 1 of Thakoor and page 3132-3133 of Thakoor make it clear that Thakoor is not a wire but merely a layer of the memistor device. The H_xWO_3 compound of Thakoor is the result of a chemical reaction wherein an influx of H+ ions react with the WO_3 layer to form the H_xWO_3 compound, whereas the nanowires of Applicant's invention are prepared in a dielectric medium and do not occur as a result of a chemical reaction. Applicant's

nanowires are pre-disposed in a dielectric medium rather than as a result of a chemical reaction as part of the process of forming the memistor device. It is also significant to note that H_xWO_3 is tungstic acid (see page 3133, left column, line 4 of Thakoor). Mixing tungstic acid with Applicant's dielectric medium does not make sense because the acid would destroy the viability of the dielectric medium.

The H_xWO_3 compound (i.e., Tungstic Acid) of Thakoor simply does not inherently or directly anticipate the nanowires of Applicant's invention. The Examiner has simply not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of a nanowire flows from the teachings from the H_xWO_3 compound of Thakoor. Thus, the H_xWO_3 compound (i.e., Tungstic Acid) of Thakoor does not anticipate the nanowires of Applicant's invention.

Argument 10

Regarding Argument 10, the Examiner asserted that the "nanoconductors" in Thakoor are "H+ions". The Examiner asserted that they are suspended in a "thin film of hygroscopic chromium trioxide" and asserted that this is a dielectric medium. Regarding the Examiner's assertion that "thin film of hygroscopic chromium trioxide" is a dielectric medium, the Applicant believes that it would be helpful to review what constitutes a "dielectric". A dielectric is a material that tends to concentrate an applied electric field (e-field) within itself. As the dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. The chromium trioxide (Cr_2O_3) of Thakoor is hygroscopic as Thakoor clearly states. A "hygroscopic" is something that attracts water. Cr_2O_3 is also a solid. A dielectric does not "attract" water. In fact, if a dielectric did attract water the water itself would damage Applicant's dielectric medium and plurality of nanoconductors

disposed in the dielectric medium, so it would not make sense to use a "hygroscopic" material such as that of Thakoor. Chromium trioxide (Cr_2O_3) does not tend to concentrate an applied electric field within itself and does not interact with the applied electric field so that charges are redistributed within atoms or molecules of the dielectric.

Additionally, it is important to note that use of H+ions and the thin film of hygroscopic chromium trioxide in order to achieve the memistor of Thakoor is electrolytic in nature. Thakoor clearly states that the thin film of hygroscopic chromium trioxide (Cr_2O_3) serves as a hydrogen ion source (see Page 3132, paragraph under heading "Experimental Details" of Thakoor). The Thakoor device is thus based on an electrolytic configuration, that is, the use of an electrolyte and not a dielectric. Thakoor, for examples, at page 3133, second column, third paragraph, specifically refers to the use of an electrolyte. The memistor of Thakoor is based on the use of the electrochemical process of electrolysis, which is the production of chemical changes by the passage of current through an <u>electrolyte</u> (not a dielectric).

An example of such an electrochemical process is described in the "Introduction" section of Thakoor, Page 3132, Column 1, lines 34 to Column 2, line 2, where Thakoor states that "...in this paper, we report on the operational characteristics and application potential of a solid-state 'memistor," an analog memory device based on the electrochemical ion transport to/from tungsten oxide in a thin-films structure. The three-terminal devices utilizes a reversible transfer of metal (hydrogen) ions in tungsten oxide..." The use of <u>electrolytes</u> is taught, for example on page 3133, column 1, lines 24-26 of Thakoor where Thakoor refers to "WO_3/<u>electrolyte</u> display". The memistor of Thakoor is based on the production of chemical changes by the passage of current through an <u>electrolyte</u>.

An electrolyte is a substance containing free <u>ions</u> which behaves as an electrically conductive medium. Electrolytes are generally composed of ions in a

solution of some sort. The use of free ions for a substance that behaves as electrically conductive medium, differs from that of a <u>dielectric</u>, which tends to concentrate an applied electric field (e-field) within itself. This is a fundamental and key difference between Thakoor and Applicant's invention. Unlike an electrolyte, such as that employed by Thakoor, as a <u>dielectric</u> interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the <u>dielectric</u> material. This is <u>not</u> true of electrolytic materials such as that used to create the memistor of Thakoor. This also not true of the hygroscopic chromium trioxide (Cr_2O_3) material of Thakoor.

Thus, to summarize, Thakoor's device is based on the use of electrolytes, whereas Applicant's device utilizes a dielectric. Additionally, the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor is not a dielectric and instead tends to attract water, which would actually damage the dielectric configuration of Applicant's invention. Based on the foregoing, and requirements of establishing inherency as a basis for anticipation, one skilled in the art would not come to the conclusion that the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor inherently anticipates the dielectric medium of Applicant's invention, because in relying upon the theory of inherency, the Examiner has not provided a basis in fact and/or technical reasoning to reasonably supporting the determination that the allegedly inherent characteristic of the use of a dielectric medium in which nanoconductors (e.g., nanotubes, nanowires, DNA, etc) are free to move about <u>necessarily</u> flows from the teachings of the Thakoor reference. The evidence provided above proves the opposite.

Argument 11

Regarding Argument 11, the Examiner asserted that as far as Applicant's claim for "nanotechnology" is concerned, the prior art anticipates this feature with H+ ions and argued that these ions are clearly measurable and verifiable to be on the

nanometer scale. The Examiner asserted that the Applicant has not brought evidence to prove that the H+ions are not on the nanometer scale, as Examiner asserts.

The Examiner argued that the "nanoconductors" in Thakoor are "H+ ions" as Applicant calls them (or "H+ ions" as the prior art calls them). The Examiner asserted that they are suspended in a "thin film of hygroscopic chromium trioxide" as the prior art calls it. The Examiner asserted that this is the same dielectric medium as Applicant's invention.

The Applicant respectfully disagrees with these assertions. First, the Applicant is not alleging that H+ ions are not on the nanometer scale. The Applicant is asserting, however, that H+ ions and "ions" in general do not constitute nanoconductors/nanoparticles taught by Applicant's invention. In order to understand why such "ions" are not nanoconductors/nanoparticles as taught by Applicant's invention, the Applicant believes that it would be helpful to the Examiner to understand what actually constitutes "nanotechnology". A general discussion of "nanotechnology" is provided in Applicant's "background" section as follows:

> "The term "Nanotechnology" generally refers to nanometer-scale manufacturing processes, materials and devices, as associated with, for example, nanometer-scale lithography and nanometer-scale information storage. Nanometer-scale components find utility in a wide variety of fields, particularly in the fabrication of microelectrical and microelectromechanical systems (commonly referred to as "MEMS"). Microelectrical nano-sized components include transistors, resistors, capacitors and other nano-integrated circuit components. MEMS devices include, for example, micro-sensors, micro-actuators, micro-instruments, micro-optics, and the like.
>
> In general, nanotechnology presents a solution to the problems faced in the rapid pace of computer chip design in recent years. According to Moore's law, the number of switches that can be produced on a computer chip has doubled every 18 months. Chips now can hold millions of transistors. However, it is becoming increasingly difficult to increase the number of elements on a chip using present technologies. At the present rate, in the next few years the theoretical limit of silicon based chips will be reached. Because the number of elements, which can be manufactured on a chip, determines the data storage and processing capabilities of microchips, new technologies are required which will allow for the development of higher performance chips.

Present chip technology is also limited in cases where wires must be crossed on a chip. For the most part, the design of a computer chip is limited to two dimensions. Each time a circuit is forced to cross another circuit, another layer must be added to the chip. This increases the cost and decreases the speed of the resulting chip. A number of alternatives to standard silicon based complementary metal oxide semiconductor ("CMOS") devices have been proposed. The common goal is to produce logic devices on a nanometer scale. Such dimensions are more commonly associated with molecules than integrated circuits.

Integrated circuits and electrical components thereof, which can be produced at a molecular and nanometer scale, include devices such as carbon nanotubes and nanowires, which essentially are nanoscale conductors ("nanoconductors"). Nanoconductors are tiny conductive tubes (i.e., hollow) or wires (i.e., solid) with a very small size scale (e.g., 0.7 to 300 nanometers in diameter and up to 1mm in length). Their structure and fabrication have been widely reported and are well known in the art. Carbon nanotubes, for example, exhibit a unique atomic arrangement, and possess useful physical properties such as one-dimensional electrical behavior, quantum conductance, and ballistic electron transport.

Carbon nanotubes are among the smallest dimensioned nanotube materials with a generally high aspect ratio and small diameter. High-quality single-walled carbon nanotubes can be grown as randomly oriented, needle-like or spaghetti-like tangled tubules. They can be grown by a number of fabrication methods, including chemical vapor deposition (CVD), laser ablation or electric arc growth. Carbon nanotubes can be grown on a substrate by catalytic decomposition of hydrocarbon containing precursors such as ethylene, methane, or benzene. Nucleation layers, such as thin coatings of Ni, Co, or Fe are often intentionally added onto the substrate surface in order to nucleate a multiplicity of isolated nanotubes. Carbon nanotubes can also be nucleated and grown on a substrate without a metal nucleating layer by using a precursor including one or more of these metal atoms. Semiconductor nanowires can be grown on substrates by similar processes."

The aforementioned language generally describes what is meant by "nanotechnology". Of course, it is understood by those in nanotechnology arts that variations to the aforementioned description and examples re: nanotechnology are likely to arise, but this description can be utilized as a general guideline for the context of "nanotechnology" in which Applicant's invention is provided.

With this in mind, Applicant has provided various examples of <u>nanoconductors</u> in Applicant's specification. For example, the Applicant has referred to <u>nanotubes</u>, <u>nanowires</u>, <u>nanoparticle</u> and even <u>DNA</u>. For example, Applicant's specification at paragraph [0087] indicates that "...Examples of nanoconductors include devices such as, for example, nanowires, nanotubes, and nanoparticles". Applicant's paragraph [0087] also indicates that "The network of nanoconnections

depicted in FIG. 3 can be implemented as a network of molecules, including, for example, nanoconductors." Applicant's specification at paragraph [0088) also indicates the following:

> "Nanoconnections 304, which are analogous to biological synapses, can be composed of electrical conducting material (i.e., nanoconductors). Nanoconductors can be provided in a variety of shapes and sizes without departing from the teachings herein. A nanoconductor can also be implemented as, for example, a molecule or groups of molecules."

Thus, Applicant's use of nanotechnology-based devices and components relates to multi-atom structures that are built (man-made or natural) or synthesized. DNA, for example, is a naturally constructed multi-atom structure. Free floating ions are not such structures. Atoms and atomic ions do not represent nanoparticles/nanoconductors because "nanotechnology" seeks to use atoms as the <u>building blocks</u> of multi-atom structures. In this light, the H+ ion of Thakoor is not a nanoconductor as taught by Applicant's invention, but rather simply just that -- an ion. Thus, it is not proper to identify the <u>ions</u> of Thakoor as anticipating the <u>nanoconductors</u> of Applicant's invention because one skilled in the art would <u>not</u> recognize an ion as constituting such a nanoconductor (i.e., built or synthesized multi-atom structures such as DNA, nanotubes, nanowires, etc). The ions of Thakoor do not inherently anticipate the nanoconductors taught by Applicant's invention because the Examiner has not provided a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic of nanoconductors (as taught by Applicant's invention) <u>necessarily</u> flows from the teachings of the applied prior art, i.e., Thakoor and the H+ ions.

Regarding the Examiner's assertion that "thin film of hygroscopic chromium trioxide" is used by Thakoor as a dielectric medium, the Applicant believes that it would be helpful to review what constitutes a "dielectric". A dielectric is a material that tends to concentrate an applied electric field within itself. As the dielectric interacts with the applied electric field, charges are redistributed within the atoms

or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. The chromium trioxide (Cr_2O_3) of Thakoor is hygroscopic as Thakoor clearly states. A "hygroscopic" is something that attracts water. Cr_2O_3 is also a solid. A dielectric does not "attract" water. In fact, if a dielectric did attract water the water itself would damage Applicant's dielectric medium and plurality of nanoconductors disposed (and free to move about) in the dielectric medium, so it would not make sense to use a "hygroscopic" material such as that of Thakoor. Chromium trioxide (Cr_2O_3) does not tend to concentrate an applied electric field within itself and does not interact with the applied electric field so that charges are redistributed within atoms or molecules of the dielectric.

Additionally, it is important to note that use of H+ions and the thin film of hygroscopic chromium trioxide in order to achieve the memistor of Thakoor is electrolytic in nature. Thakoor clearly states that the thin film of hygroscopic chromium trioxide (Cr_2O_3) serves as a hydrogen ion source (see Page 3132, paragraph under heading "Experimental Details" of Thakoor). The Thakoor device is thus based on an electrolytic configuration, that is, the use of an electrolyte and not a dielectric. Thakoor, for examples, at page 3133, second column, third paragraph, specifically refers to the use of an electrolyte. The memistor of Thakoor is based on the use of the electrochemical process of electrolysis, which is the production of chemical changes by the passage of current through an <u>electrolyte</u> (not a dielectric).

An example of such an electrochemical process is described in the "Introduction" section of Thakoor, Page 3132, Column 1, lines 34 to Column 2, line 2, where Thakoor states that "...in this paper, we report on the operational characteristics and application potential of a solid-state 'memistor," an analog memory device based on the electrochemical ion transport to/from tungsten oxide in a thin-films structure. The three-terminal devices utilizes a reversible transfer of

metal (hydrogen) ions in tungsten oxide..." The use of electrolytes is taught, for example on page 3133, column 1, lines 24-26 of Thakoor where Thakoor refers to "WO_3/electrolyte display". The memistor of Thakoor is based on the production of chemical changes by the passage of current through an electrolyte.

An electrolyte is a substance containing free ions which behaves as an electrically conductive medium. Electrolytes are generally composed of ions in a solution of some sort. The use of free ions for a substance that behaves as electrically conductive medium, differs from that of the use of a dielectric, which tends to concentrate an applied electric field (e-field) within itself. This is a fundamental and key difference between Thakoor and Applicant's invention. Unlike an electrolyte, such as that employed by Thakoor, as a dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. This is not true of electrolytic materials such as that used to create the memistor of Thakoor. This also not true of the hygroscopic chromium trioxide (Cr_2O_3) material of Thakoor.

Thus, to summarize, Thakoor's device is based on the use of electrolytes, whereas Applicant's device is based on the use of a dielectric. Additionally, the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor tends to attract water, which would actually damage the dielectric configuration of Applicant's invention. Cr_2O_3 reacts with water, a strong acid is produced, which would corrode Applicant's nanoconductors, so it would not make sense to use Cr_2O_3 as a dielectric in which nanoconductors (e.g., nanowires, nanotubes, DNA, etc.) are free to move about. Based on the foregoing, and requirements of establishing inherency as a basis for anticipation, one skilled in the art would not come to the conclusion that the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor inherently anticipates the use of a dielectric medium of Applicant's invention, because in relying upon the theory of inherency, the Examiner has not provided a basis in fact and/or technical reasoning

to reasonably supporting the determination that the allegedly inherent characteristic of the use of a dielectric medium (in which nanoconductors are free to move about) necessarily flows from the teachings of the Thakoor reference. The evidence provided above proves the opposite.

Regarding Applicant's claim for "Hebbian learning" the Examiner argued that Thakoor on page 3133, left column, lines 1-14, "teaches the growing or lessening the conductivity of the resistance put a field to adjust the memory". The Examiner argued that such teaching, to one of ordinary skill in the art, can clearly be a learning mechanism. The Applicant asks, wow does feature of Thakoor constitute a "learning mechanism"? How is "learning accomplished by "the growing or lessening the conductivity of the resistance put a field to adjust the memory" of Thakoor. Simply adjusting memory is not "learning". Learning is much more sophisticated and complicated process, which is not achieved simply "adjusting memory". Additionally, and even more importantly, how does such a feature of Thakoor inherently anticipate Hebbian learning?

To one of ordinary skill in the art, Thakoor on page 3133, left column, lines 1-14, provides no hint, teaching or disclosure of "Hebbian Learning". In fact, Thakoor on page 3133, left column, lines 1-14 also does not clearly provide for a teaching of a learning mechanism. Applicant's Hebbian learning mechanism must operate in a very specific manner in order to provide for Hebbian learning. In order to understand what Hebbian learning is, the Applicant believes it would be helpful to provide a brief overview of Hebbian learning.

Hebbian learning is based on Hebbian theory, which describes a basic mechanism for synaptic plasticity wherein an increase in synaptic efficacy arises from the presynaptic cell's *repeated* and *persistent* stimulation of the postsynaptic cell. Introduced by Donald Hebb in 1949, it is also called Hebb's rule and is referred to as Hebbian learning as well. Also known as cell assembly theory, the theory is

often summarized as *cells that fire together, wire together*, although this is an oversimplification of the nervous system not to be taken literally.

From the point of view of artificial neurons and artificial neural networks, Hebb's principle can be described as a method of determining how to alter the weights between model neurons as a function of their correlations of their activity in time. The weight between two neurons will increase if the two neurons activate simultaneously (they are correlated); it is reduced if they activate separately. Nodes which tend to be either both positive or both negative at the same time will have strong positive weights while those which tend to be opposite will have strong negative weights. It is sometimes stated more simply as "neurons that fire together, wire together."

This original principle is perhaps the simplest form of weight selection. While this means it can be relatively easily coded into a computer program and used to update the weights for a network, it also prohibits the number of applications of Hebbian learning, at least with respect to software simulations of neural networks. This is because large neural networks contain massive numbers of synapses and the modification of the synapse in the traditional computing paradigm requires accessing memory. This memory access requires extraordinarily more energy than a physical neural network where synaptic states do not have to be "accessed". Today, the term *Hebbian learning* generally refers to some form of mathematical abstraction of the original principle proposed by Hebb. In this sense, Hebbian learning involves weights between learning nodes being adjusted so that each weight better represents the relationship between the nodes. As such, many learning methods can be considered to be somewhat Hebbian in nature.

The following is a formulaic description of Hebbian learning: (note that many other descriptions are possible)

$$w_{ij} = x_i x_j$$

where w_{ij} is the weight of the connection from neuron j to neuron i and x_i the input for neuron i. Note that this is pattern learning (weights updated after every training example). In a Hopfield network, connections w_{ij} are set to zero if $i = j$ (no reflexive connections allowed). With binary neurons (activations either 0 or 1), connections would be set to 1 if the connected neurons have the same activation for a pattern.

Another formulaic description is:

$$w_{ij} = \frac{1}{n} \sum_{k=1}^{p} x_i^k x_j^k ,$$

where w_{ij} is the weight of the connection from neuron j to neuron i, n is the dimension of the input vector, p the number of training patterns, and x_i^k the kth input for neuron i. The Applicant invites the Examiner to view the following web site, which contains a good general overview of Hebbian learning:

http://en.wikipedia.org/wiki/Hebbian_learning

Based on a review of Thakoor and a basic understanding of Hebbian learning it is very clear that Thakoor does not provide for any teaching, suggestion or disclosure of Hebbian learning. Additionally, it is very clear that Thakoor does not inherently anticipate Hebbian learning, and thus the Hebbian learning mechanism provided by Applicant's invention. The Examiner has not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory"

Argument 12

Regarding Argument 12, the Examiner argued that the "nanoconductors" in Thakoor are "H + ions" and additionally that they are suspended in a thin film of hygroscopic chromium trioxide and argued that this thin film is the same dielectric medium of Applicant's invention. The Examiner asserted that the dielectric solvent is disclosed as a "hygroscopic i.e. moisture film" in Thakoor.

Regarding the Examiner's assertion that "thin film of hygroscopic chromium trioxide" is used as a dielectric medium in which nanoconductors (e.g., nanowires, nanotubes, DNA, etc) are free to move about, the Applicant believes that it would be helpful to review what constitutes a "dielectric". A dielectric is a material that tends to concentrate an applied electric field within itself. As the dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. The chromium trioxide (Cr_2O_3) of Thakoor is hygroscopic as Thakoor clearly states. A "hygroscopic" is something that attracts water. Cr_2O_3 is also a solid. A dielectric does not "attract" water. In fact, if a dielectric did attract water the water itself would damage Applicant's dielectric medium and plurality of nanoconductors disposed in the dielectric medium, so it would not make sense to use a "hygroscopic" material such as that of Thakoor. Chromium trioxide (Cr_2O_3) does not tend to concentrate an applied electric field within itself and does not interact with the applied electric field so that charges are redistributed within atoms or molecules of the dielectric.

Additionally, it is important to note that use of H+ions and the thin film of hygroscopic chromium trioxide in order to achieve the memistor of Thakoor is electrolytic in nature. Thakoor clearly states that the thin film of hygroscopic chromium trioxide (Cr_2O_3) serves as a <u>hydrogen ion source</u> (see Page 3132, paragraph under heading "Experimental Details" of Thakoor). The Thakoor device is thus based on an electrolytic configuration, that is, the use of an electrolyte and

not a dielectric. Thakoor, for examples, at page 3133, second column, third paragraph, specifically refers to the use of an electrolyte. The memistor of Thakoor is based on the use of the electrochemical process of electrolysis, which is the production of chemical changes by the passage of current through an electrolyte (not a dielectric).

An example of such an electrochemical process is described in the "Introduction" section of Thakoor, Page 3132, Column 1, lines 34 to Column 2, line 2, where Thakoor states that "...in this paper, we report on the operational characteristics and application potential of a solid-state 'memistor," an analog memory device based on the electrochemical ion transport to/from tungsten oxide in a thin-films structure. The three-terminal devices utilizes a reversible transfer of metal (hydrogen) ions in tungsten oxide..." The use of electrolytes is taught, for example on page 3133, column 1, lines 24-26 of Thakoor where Thakoor refers to "WO_3/electrolyte display". The memistor of Thakoor is based on the production of chemical changes by the passage of current through an electrolyte.

An electrolyte is a substance containing free ions which behaves as an electrically conductive medium. Electrolytes are generally composed of ions in a solution of some sort. The use of free ions for a substance that behaves as electrically conductive medium, differs from that of a dielectric, which tends to concentrate an applied electric field (e-field) within itself. This is a fundamental and key difference between Thakoor and Applicant's invention. Unlike an electrolyte, such as that employed by Thakoor, as a dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electrical field both inside and in the region near the dielectric material. This is not true of electrolytic materials such as that used to create the memistor of Thakoor. This also not true of the hygroscopic chromium trioxide (Cr_2O_3) material of Thakoor, which can produce an acid that is corrosive to applicant's nanoconductors (e.g., nanotubes, nanowires, DNA, etc.).

Thus, to summarize, Thakoor's device is based on the use of electrolytes, whereas Applicant's device utilizes a dielectric medium in which nanoconductors are free to move about. Additionally, the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor is not used as a dielectric and instead tends to attract water, which would actually damage Applicant's invention as indicate previously. Based on the foregoing, and requirements of establishing inherency as a basis for anticipation, one skilled in the art would not come to the conclusion that the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor inherently anticipates the sue of the dielectric medium of Applicant's invention, because in relying upon the theory of inherency, the Examiner has not provided a basis in fact and/or technical reasoning to reasonably supporting the determination that the allegedly inherent characteristic of the use of a dielectric medium <u>necessarily</u> flows from the teachings of the Thakoor reference. The evidence provided above proves the opposite.

Regarding Applicant's claim for "Hebbian learning" the Examiner argued that Thakoor on page 3133, left column, lines 1-14, "teaches the growing or lessening the conductivity of the resistance put a field to adjust the memory". The Examiner argued that such teaching, to one of ordinary skill in the art, can clearly be a learning mechanism. The Applicant asks, wow does feature of Thakoor constitute a "learning mechanism"? How is "learning accomplished by "the growing or lessening the conductivity of the resistance put a field to adjust the memory" of Thakoor. Simply adjusting memory is not "learning". Learning is much more sophisticated and complicated process, which is not achieved simply "adjusting memory". Additionally, and even more importantly, how does such a feature of Thakoor inherently anticipate <u>Hebbian</u> learning?

To one of ordinary skill in the art, Thakoor on page 3133, left column, lines 1-14, provides no hint, teaching or disclosure of "Hebbian Learning". In fact, Thakoor on page 3133, left column, lines 1-14 also does not clearly provide for a teaching of a <u>learning</u> mechanism. Applicant's <u>Hebbian</u> learning mechanism must operate in a

very specific manner in order to provide for Hebbian learning. In order to understand what Hebbian learning is, the Applicant believes it would be helpful to provide a brief overview of Hebbian learning.

Hebbian learning is based on Hebbian theory, which describes a basic mechanism for synaptic plasticity wherein an increase in synaptic efficacy arises from the presynaptic cell's *repeated* and *persistent* stimulation of the postsynaptic cell. Introduced by Donald Hebb in 1949, it is also called Hebb's rule and is referred to as Hebbian learning as well. Also known as cell assembly theory, the theory is often summarized as *cells that fire together, wire together*, although this is an oversimplification of the nervous system not to be taken literally.

From the point of view of artificial neurons and artificial neural networks, Hebb's principle can be described as a method of determining how to alter the weights between model neurons as a function of their correlations of their activity in time. The weight between two neurons will increase if the two neurons activate simultaneously (they are correlated); it is reduced if they activate separately. Nodes which tend to be either both positive or both negative at the same time will have strong positive weights while those which tend to be opposite will have strong negative weights. It is sometimes stated more simply as "neurons that fire together, wire together."

This original principle is perhaps the simplest form of weight selection. While this means it can be relatively easily coded into a computer program and used to update the weights for a network, it also prohibits the number of applications of Hebbian learning, at least with respect to software simulations of neural networks. This is because large neural networks contain massive numbers of synapses and the modification of the synapse in the traditional computing paradigm requires accessing memory. This memory access requires extraordinarily more energy than a physical neural network where synaptic states do not have to be "accessed". Today, the term *Hebbian learning* generally refers to some form of mathematical

abstraction of the original principle proposed by Hebb. In this sense, Hebbian learning involves weights between learning nodes being adjusted so that each weight better represents the relationship between the nodes. As such, many learning methods can be considered to be somewhat Hebbian in nature.

The following is a formulaic description of Hebbian learning: (note that many other descriptions are possible)

$$w_{ij} = x_i x_j$$

where w_{ij} is the weight of the connection from neuron j to neuron i and x_i the input for neuron i. Note that this is pattern learning (weights updated after every training example). In a Hopfield network, connections w_{ij} are set to zero if $i = j$ (no reflexive connections allowed). With binary neurons (activations either 0 or 1), connections would be set to 1 if the connected neurons have the same activation for a pattern.

Another formulaic description is:

$$w_{ij} = \frac{1}{n} \sum_{k=1}^{p} x_i^k x_j^k \quad ,$$

where w_{ij} is the weight of the connection from neuron j to neuron i, n is the dimension of the input vector, p the number of training patterns, and x_i^k the kth input for neuron i. The Applicant invites the Examiner to view the following web site, which contains a good general overview of Hebbian learning:

http://en.wikipedia.org/wiki/Hebbian_learning

Based on a review of Thakoor and a basic understanding of Hebbian learning it is very clear that Thakoor does not provide for any teaching, suggestion or disclosure of Hebbian learning. Additionally, it is very clear that Thakoor does not inherently anticipate Hebbian learning, and thus the Hebbian learning mechanism provided by Applicant's invention. The Examiner has not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the

allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory".

Argument 13

The Examiner asserted that regarding Applicant's claim for Hebbian learning, Thakoor on page 3313, left column, lines 1-14 teaches "the growing or lessening the conductivity of the resistance put a field to adjust the memory". The Examiner further stated that regardless of whether Applicant agrees, such teaching, to one of ordinary skill in the art can clearly be a learning mechanism, i.e., Hebbian learning.

As indicated previously Thakoor on page 3313, left column, lines 1-14 does not provide any hint, suggestion or teaching of a learning mechanism. Thakoor also does not provide any teaching of Hebbian learning.

The Applicant asks, how does Thakoor on page 3313, left column, lines 1-14 provide for a teaching of a learning mechanism as taught by Applicant's invention? Where does the learning take place at Thakoor on page 3133, left column, lines 1-14? How is "learning" accomplished by "the growing or lessening the conductivity of the resistance put a field to adjust the memory" of Thakoor. Simply adjusting memory is not "learning". Learning is much more sophisticated and complicated process, which is not achieved simply "adjusting memory". Additionally, and even more importantly, how does such a feature of Thakoor inherently anticipate <u>Hebbian</u> learning?

To one of ordinary skill in the art, Thakoor on page 3133, left column, lines 1-14, provides no hint, teaching or disclosure of "Hebbian Learning". In fact, Thakoor on page 3133, left column, lines 1-14 also does not clearly provide for a teaching of a <u>learning</u> mechanism. Applicant's <u>Hebbian</u> learning mechanism must operate in a very specific manner in order to provide for <u>Hebbian</u> learning. In order to

understand what Hebbian learning is, the Applicant believes it would be helpful to provide a brief overview of Hebbian learning.

Hebbian learning is based on Hebbian theory, which describes a basic mechanism for synaptic plasticity wherein an increase in synaptic efficacy arises from the presynaptic cell's *repeated* and *persistent* stimulation of the postsynaptic cell. Introduced by Donald Hebb in 1949, it is also called Hebb's rule and is referred to as Hebbian learning as well. Also known as cell assembly theory, the theory is often summarized as *cells that fire together, wire together*, although this is an oversimplification of the nervous system not to be taken literally.

From the point of view of artificial neurons and artificial neural networks, Hebb's principle can be described as a method of determining how to alter the weights between model neurons as a function of their correlations of their activity in time. The weight between two neurons will increase if the two neurons activate simultaneously (they are correlated); it is reduced if they activate separately. Nodes which tend to be either both positive or both negative at the same time will have strong positive weights while those which tend to be opposite will have strong negative weights. It is sometimes stated more simply as "neurons that fire together, wire together."

This original principle is perhaps the simplest form of weight selection. While this means it can be relatively easily coded into a computer program and used to update the weights for a network, it also prohibits the number of applications of Hebbian learning, at least with respect to software simulations of neural networks. This is because large neural networks contain massive numbers of synapses and the modification of the synapse in the traditional computing paradigm requires accessing memory. This memory access requires extraordinarily more energy than a physical neural network where synaptic states do not have to be "accessed". Today, the term *Hebbian learning* generally refers to some form of mathematical abstraction of the original principle proposed by Hebb. In this sense, Hebbian

learning involves weights between learning nodes being adjusted so that each weight better represents the relationship between the nodes. As such, many learning methods can be considered to be somewhat Hebbian in nature.

The following is a formulaic description of Hebbian learning: (note that many other descriptions are possible)

$$w_{ij} = x_i x_j$$

where w_{ij} is the weight of the connection from neuron j to neuron i and x_i the input for neuron i. Note that this is pattern learning (weights updated after every training example). In a Hopfield network, connections w_{ij} are set to zero if $i = j$ (no reflexive connections allowed). With binary neurons (activations either 0 or 1), connections would be set to 1 if the connected neurons have the same activation for a pattern.

Another formulaic description is:

$$w_{ij} = \frac{1}{n} \sum_{k=1}^{p} x_i^k x_j^k ,$$

where w_{ij} is the weight of the connection from neuron j to neuron i, n is the dimension of the input vector, p the number of training patterns, and x_i^k the kth input for neuron i. The Applicant invites the Examiner to view the following web site, which contains a good general overview of Hebbian learning:

http://en.wikipedia.org/wiki/Hebbian_learning

Based on a review of Thakoor and a basic understanding of Hebbian learning it is very clear that Thakoor does not provide for any teaching, suggestion or disclosure of Hebbian learning. Additionally, it is very clear that Thakoor does not inherently anticipate Hebbian learning, and thus the Hebbian learning mechanism provided by Applicant's invention. The Examiner has not provided a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the

teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory".

As far as Applicant's claim for "Hebbian plasticity" or "anti-Hebbian plasticity" is concerned, the Examiner argued that the prior art anticipates this feature in FIG. 2 of Thakoor. The Examiner asserted that FIG. 2 illustrates the variation in resistance with time for several different control voltages. The Examiner asserted that plasticity by definition is the ability to develop or adapt in response to the environment. The Examiner further stated that "another word, the ability to learn or unlearn". The Examiner also stated that "as responded above regarding Hebbian learning, the growing or lessening the conductivity of the resistance put a field to adjust the memory". The Examiner therefore argued that the learning or unlearning is being performed.

The Applicant respectfully disagrees with this assessment and notes that the arguments provided above against the Examiner's assertions with respect to Argument 2 and the issue of the Hebbian learning mechanism apply equally against the Examiner's assertions with respect to Argument 13. In the interest of brevity, the Applicant will not repeat these arguments, except to point out again that the Examiner has not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor, and in particular, the Examiner's citation of Thakoor on page 3133, left column, lines 1-14, citing "the growing or lessening the conductivity of the resistance put a field to adjust the memory". One of ordinary skill in the art would not see this as teaching or inherently anticipating <u>Hebbian</u> learning. Hebbian learning is a very specific type of neural network learning mechanism, and there is not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent

characteristic of Hebbian learning <u>necessarily</u> flows from the teachings from Thakoor. Simply "growing or lessening the conductivity of the resistance put a field to adjust the memory" does not inherently anticipate the Hebbian learning mechanism of Applicant's invention.

Regarding "Hebbian plasticity" or "anti-Hebbian plasticity," a review of FIG. 2 of Thakoor does not indicate any suggestion, disclosure and/or teaching of Hebbian plasticity or anti-Hebbian plasticity. The Examiner argued that "plasticity" is the ability to develop or adapt in response to the environment, or the ability to learn or unlearn. This is an oversimplification of a concept that is inherently more complex and sophisticated than the definition provided by the Examiner. FIG. 2 of Thakoor is simply a plot of resistance versus time for several control voltages for a turning the device "on" and "off". Thakoor. FIG. 2 does not suggest, disclose or teach any sort of "learning" or "unlearning". The Examiner has merely made a statement that FIG. 2 illustrates an ability to learn or adapting to the environment and hence illustrates "learning". FIG. 2 merely describes "turn-on" and "turn-off" characteristics of the Thakoor device, but does not illustrate a device that has the ability to develop or adapt in response to the environment. The Examiner's arguments do not adequately explain how one skilled in the art would identify FIG. 2 as illustrating plasticity and more importantly, Hebbian plasticity or anti-Hebbian plasticity or the performance of any sort of "learning" or "unlearning". Based on the foregoing, the Applicant submits that there is simply not a basis in fact and/or technical reasoning for reasonably supporting a determination that the allegedly inherent characteristic of Hebbian plasticity or anti-Hebbian plasticity flows from the teachings from the test device programming characteristics for variations in resistance of test device with time for several different control voltages of Thakoor's FIG. 2. Thus, FIG. 2 of Thakoor does not anticipate Hebbian and/or anti-Hebbian plasticity, nor learning/unlearning nor even plasticity.

Argument 14

Regarding Argument 14, the Examiner asserted that Applicant's argument is merely a general denial of the rejection and does not address the components pointed out by the Examiner. The Examiner stated that "Figure 3 clearly indicates 'a circuit utilizing a WO_3, thin film memistor."

The Examiner asserted that as responded above, the "nanoconductors" in Thakoor are "H+ ions". The Examiner argued that Figure 3 of Thakoor anticipates Applicant's claim of an integrated circuit chip utilizing nanotechnology.

The Applicant respectfully disagrees with these assertions. First, the Applicant is not alleging that H+ ions are not on the nanometer scale. The Applicant is asserting, however, that H+ ions and "ions" in general do not constitute nanoconductors/nanoparticles taught by Applicant's invention. In order to understand why such "ions" are not nanoconductors/nanoparticles as taught by Applicant's invention, the Applicant believes that it would be helpful to the Examiner to understand what actually constitutes "nanotechnology". A general discussion of "nanotechnology" is provided in Applicant's "background" section as follows:

"The term "Nanotechnology" generally refers to nanometer-scale manufacturing processes, materials and devices, as associated with, for example, nanometer-scale lithography and nanometer-scale information storage. Nanometer-scale components find utility in a wide variety of fields, particularly in the fabrication of microelectrical and microelectromechanical systems (commonly referred to as "MEMS"). Microelectrical nano-sized components include transistors, resistors, capacitors and other nano-integrated circuit components. MEMS devices include, for example, micro-sensors, micro-actuators, micro-instruments, micro-optics, and the like.

In general, nanotechnology presents a solution to the problems faced in the rapid pace of computer chip design in recent years. According to Moore's law, the number of switches that can be produced on a computer chip has doubled every 18 months. Chips now can hold millions of transistors. However, it is becoming increasingly difficult to increase the number of elements on a chip using present technologies. At the present rate, in the next few years the theoretical limit of silicon based chips will be reached. Because the number of elements, which can be manufactured on a chip, determines the data storage and processing capabilities of microchips, new technologies are required which will allow for the development of higher performance chips.

Present chip technology is also limited in cases where wires must be crossed on a chip. For the most part, the design of a computer chip is limited to two dimensions. Each time a circuit is forced to cross another circuit, another layer must be added to the chip. This increases the cost and decreases the speed of the resulting chip. A number of alternatives to standard silicon based complementary metal oxide semiconductor ("CMOS") devices have been proposed. The common goal is to produce logic devices on a nanometer scale. Such dimensions are more commonly associated with molecules than integrated circuits.

Integrated circuits and electrical components thereof, which can be produced at a molecular and nanometer scale, include devices such as carbon nanotubes and nanowires, which essentially are nanoscale conductors ("nanoconductors"). Nanoconductors are tiny conductive tubes (i.e., hollow) or wires (i.e., solid) with a very small size scale (e.g., 0.7 to 300 nanometers in diameter and up to 1mm in length). Their structure and fabrication have been widely reported and are well known in the art. Carbon nanotubes, for example, exhibit a unique atomic arrangement, and possess useful physical properties such as one-dimensional electrical behavior, quantum conductance, and ballistic electron transport.

Carbon nanotubes are among the smallest dimensioned nanotube materials with a generally high aspect ratio and small diameter. High-quality single-walled carbon nanotubes can be grown as randomly oriented, needle-like or spaghetti-like tangled tubules. They can be grown by a number of fabrication methods, including chemical vapor deposition (CVD), laser ablation or electric arc growth. Carbon nanotubes can be grown on a substrate by catalytic decomposition of hydrocarbon containing precursors such as ethylene, methane, or benzene. Nucleation layers, such as thin coatings of Ni, Co, or Fe are often intentionally added onto the substrate surface in order to nucleate a multiplicity of isolated nanotubes. Carbon nanotubes can also be nucleated and grown on a substrate without a metal nucleating layer by using a precursor including one or more of these metal atoms. Semiconductor nanowires can be grown on substrates by similar processes."

The aforementioned language generally describes what is meant by "nanotechnology". Of course, it is understood by those in nanotechnology arts that variations to the aforementioned description and examples re: nanotechnology are likely to arise, but this description can be utilized as a general guideline for the context of "nanotechnology" in which Applicant's invention is provided.

With this in mind, Applicant has provided various examples of <u>nanoconductors</u> in Applicant's specification. For example, the Applicant has referred to <u>nanotubes</u>, <u>nanowires</u>, <u>nanoparticle</u> and even <u>DNA</u>. For example, Applicant's specification at paragraph [0087] indicates that "...Examples of nanoconductors include devices such as, for example, nanowires, nanotubes, and nanoparticles". Applicant's paragraph [0087] also indicates that "The network of nanoconnections

depicted in FIG. 3 can be implemented as a network of molecules, including, for example, nanoconductors." Applicant's specification at paragraph [0088) also indicates the following:

> "Nanoconnections 304, which are analogous to biological synapses, can be composed of electrical conducting material (i.e., nanoconductors). Nanoconductors can be provided in a variety of shapes and sizes without departing from the teachings herein. A nanoconductor can also be implemented as, for example, a molecule or groups of molecules."

Thus, Applicant's use of nanotechnology-based devices and components relates to multi-atom structures that are built (man-made or natural) or synthesized. DNA, for example, is a naturally constructed multi-atom structure. Free floating ions are not such structures. Atoms and atomic ions do not represent nanoparticles/nanoconductors because "nanotechnology" seeks to use atoms as the <u>building blocks</u> of multi-atom structures. In this light, the H+ ion of Thakoor is not a nanoconductor as taught by Applicant's invention, but rather simply just that -- an ion. Thus, it is not proper to identify the <u>ions</u> of Thakoor as anticipating the <u>nanoconductors</u> of Applicant's invention because one skilled in the art would <u>not</u> recognize an ion as constituting such a nanoconductor (i.e., built or synthesized multi-atom structures such as DNA, nanotubes, nanowires, etc). The ions of Thakoor do not inherently anticipate the nanoconductors taught by Applicant's invention because the Examiner has not provided a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic of nanoconductors (as taught by Applicant's invention) <u>necessarily</u> flows from the teachings of the applied prior art, i.e., Thakoor and the H+ ions.

The Applicant also notes that as indicated previously, the thin-film memistor of Thakoor is neither a synapse nor a physical neural network, but is a device that complements a neuron. The memistor of Thakoor does not inherently anticipate the synapse and/or physical neural network taught by Applicant's invention because the Examiner has not provided a basis in fact and/or technical reasoning to

reasonably support the determination that the allegedly inherent characteristic of a physical neural network and/or synapse (as taught by Applicant's invention) necessarily flows from the teachings of the applied prior art, i.e., the thin film memistor device.

Argument 15

Regarding Argument 15, the Examiner attempted to remind the Examiner that the Thakoor reference teaches all of the clam limitations of the claims from which claims 8 and 12 depend. The Applicant already has provided evidence that this is not the case. Thakoor does not teach the physical neural network, the dielectric medium, the nanoconductors, the Hebbian learning mechanism and other features of Applicant's invention. There is simply no disclosure and teaching of ALL of these claim limitations in Thakoor. The Examiner argued, however, that Thakoor is properly combined with Srivastava as a basis for a rejection to claims 8 and 12 under 35 U.S.C. 103.

The Examiner directed the Applicant to page 10 of the Office Action where the teaching or suggestion to make the combination is found within the prior art itself. (Yes, but where is the teaching or suggestion found in the prior art?)

Regarding the Applicant's argument that the Office Action has not provided an explanation of a "reasonable expectation of success", the Examiner argued that MPEP 2143 does not require the Examiner to provide an explanation, but instead stated that "Applicants may present evidence showing there was not a reasonable expectation of success."

There is plenty of evidence found in the prior art references cited by the Examiner to demonstrate that there is not a reasonable expectation of success for combining the references as argued by the Examiner. First, combining the carbon nanotubes of Srivastava with Thakoor would mean somehow injecting or combining (which is not event hinted at in either reference how this would be accomplished)

such nanotubes into or with the hygroscopic chromium trioxide (Cr_2O_3) of Thakoor. Thakoor also teaches that the Cr_2O_3 is used by Thakoor as a hydrogen ion source. The Applicant further again notes that chromium trioxide is a solid. How would such nanotubes be successfully combined with such a solid? The chromium trioxide (Cr_2O_3) of Thakoor is hygroscopic as Thakoor clearly states. A "hygroscopic" is something that attracts water. Cr_2O_3 is also a <u>solid</u>. A dielectric does not "attract" water. In fact, if chromium trioxide were mixed with water, it would form a strong acid that would corrode the nanotubes of Srivastava. If the nanotubes of Srivastava would be corroded by the resulting acid of Thakoor, why would one skilled in the art be motivated to combine Thakoor with Srivastava? Additionally, where is the suggestion in either Srivastava or Thakoor that such nanotubes could be combined with a solid such as that of chromium trioxide to provide for the essential claim elements of Applicant's invention of nanoconductors that are <u>free to move about</u> in a dielectric medium? How can the nanotubes of Srivastava freely move about in the solid chromium trioxide of Thakoor?

Combining nanotubes to freely move about in such a solid would be very difficult based on a reading of both the Srivastava and Thakoor references. Chromium trioxide is a dark-red, odorless flakes or powder. Thus, it is a solid. More importantly, chromium trioxide is an acid and is often referred to as chromic acid. Ethanol, for example, will ignite on contact with it. What happens when the nanotubes of Srivastava are combined with the chromic acid of Thakoor? The resulting acid of hygroscopic chromium trioxide will corrode the nanotubes of Srivastava and renders them useless. One skilled in the art would realize this. As such, Applicant submits that there is simply no reason or motivation for one skilled in the art to combine the references as argued by the Examiner to provide for a teaching of all of the claim limitations of Applicant's invention.

V. Amendments to Claims and Specification

The Applicant has amended claim 18 and the specification as indicated herein. It is believed that such amendments do not require the Examiner to provide for a new art search, but are merely clarifying in nature and designed to correct some minor errors. It is further submitted that such amendments are for the purpose of placing the claims in condition for allowance. The Applicant therefore respectfully requests entry of these amendments as they do not raise any issues that will require a new search on the part of the Examiner.

VI. Conclusion

In view of the foregoing discussion, the Applicant has responded to each and every rejection of the Official Action. The Applicant has amended the claims in order to place the claims in condition for allowance. The Applicant has also clarified the structural distinctions of the present invention from the prior art cited by the Examiner.

Applicant respectfully requests the withdrawal of the rejections under 35 U.S.C. §102 and §103 based on the preceding remarks. Reconsideration and allowance of Applicant's application is also respectfully solicited.

Should there be any outstanding matters that need to be resolved, the Examiner is respectfully requested to contact the undersigned representative to conduct an interview in an effort to expedite prosecution in connection with the present application.

Respectfully submitted,

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Dated: November 30, 2006

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